FEBRUARY 1958

Journal of Engineering

Published by the American Society of Agricultural Engineers

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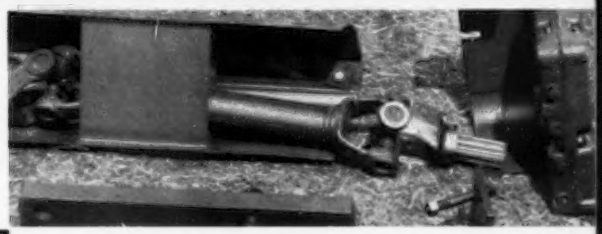

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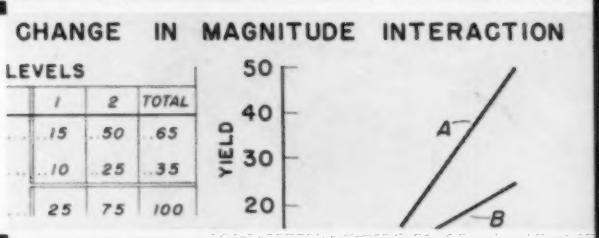

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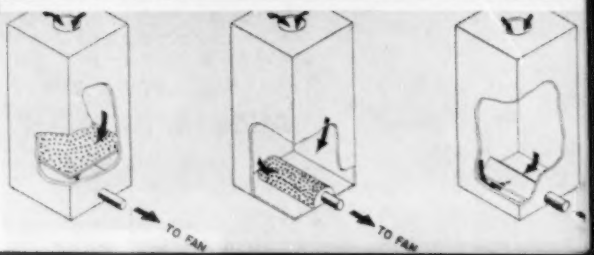

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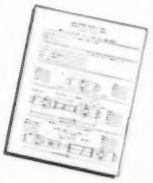
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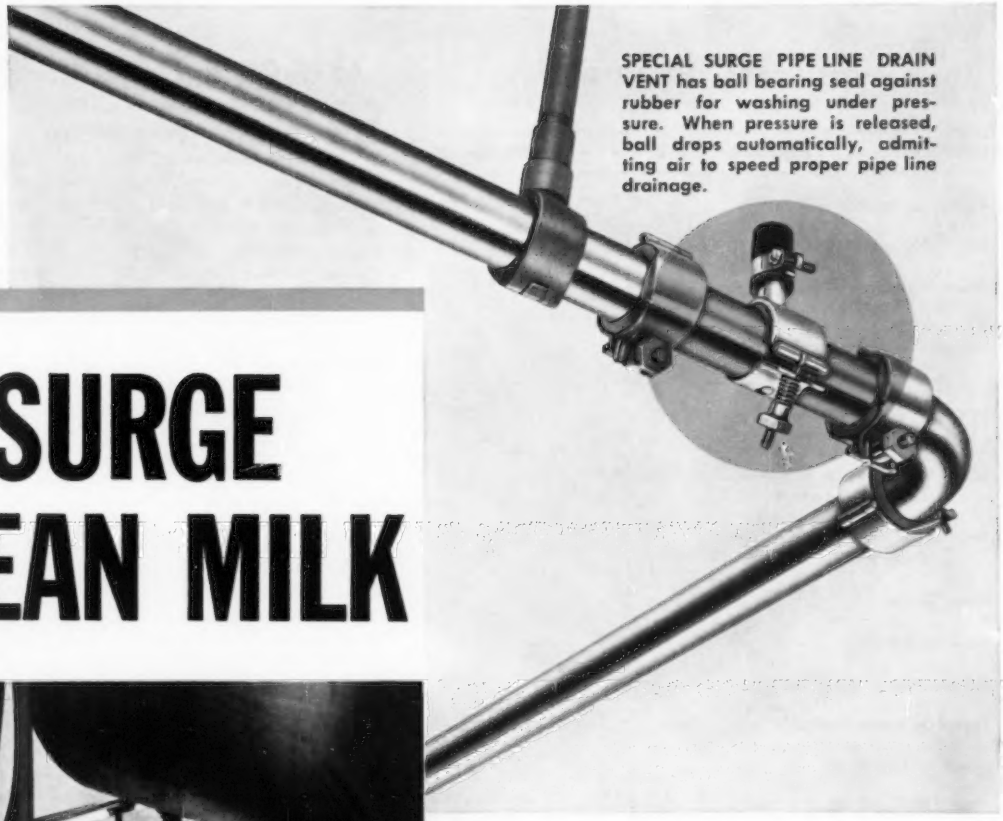
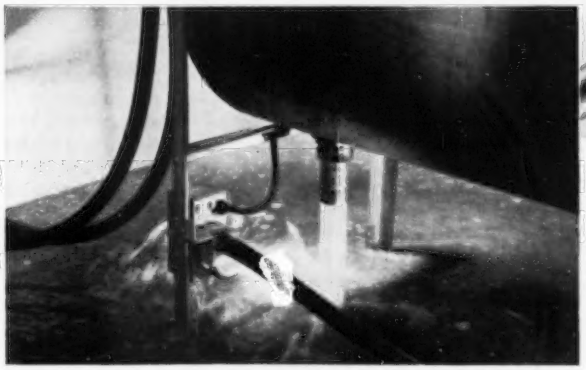


SPECIAL SURGE PIPE LINE DRAIN VENT has ball bearing seal against rubber for washing under pressure. When pressure is released, ball drops automatically, admitting air to speed proper pipe line drainage.

SURGE CLEAN MILK



. . . *plus automatic draining*

No matter what kind of pipe line milker is used—the law will compel a dairy farmer to wash it thoroughly after every milking . . . the law will compel a dairy farmer to keep it clean . . . and the law will compel him to produce clean milk. So why bother with automatic draining? . . . all it does is cut a few minutes off washup time while making sure the line is better drained.

Surge doesn't have to build a pipe line that drains automatically. Nobody but Surge does . . . why should Surge? By using a wrench for a few minutes after every milking, any dairy farmer can do a fairly good job of draining his pipe line . . . if . . . he doesn't get in too much of a hurry . . . if he doesn't get careless.

The trouble is with that "if." Every extra minute used in washup adds up to a LOT of days over the years with twice-a-day milking. So minutes do count. Surge automatic draining will save several months of time . . . as well as guaranteeing a cleaner pipe line.

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Agricultural Engineering

Established 1920

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ASEE College-Industry Conference

SOMEONE might have given the American public an "I told you so," but no one did.

For nine years before the sputnik beep-beeped its message to the world, engineering educators, practicing engineers, and other executives had held annual conferences to review the problems and progress of engineering education, its supporting sciences, and its public significance. The conferences were open. The information was public. But the public was not ready to be informed, or to give the support invited.

In dealing with a now popular subject, the tenth annual College-Industry Conference proceeded in its characteristic atmosphere of cool, practical, realistic objectivity. It was a refreshing relief from the alarmed clamor, name-calling, and blame-placing reactions of spokesmen for the public who have recently awakened to a sense of personal peril.

Sponsored by the Relations with Industry Division of the American Society for Engineering Education, this year's conference was held at the University of Michigan, January 30 and 31. More than 400 attended, representing a wide cross section of engineering colleges and industry. Attention was concentrated on the theme of "New Concepts in the Education and Development of Technical Manpower."

Basic concepts presented from the President's Committee on Education Beyond High School called for increased respect for learning, respect for the teaching profession, and respect for the learner's right to differentiated educational opportunities which recognize and provide for optimum development of individual abilities.

A luncheon address on new concepts in engineering emphasized the points that (1) fear cannot be a primary motive for education, (2) engineers need broad training to work effectively in changing areas of interest and with the changing hardware of engineering, and (3) the proportion of professional engineers needed in industry will increase with the increasing proportion of skilled labor being utilized.

A session on new concepts in motivation of technical personnel introduced new guides to the human incentives which stimulate technical personnel to continued development and most effective work.

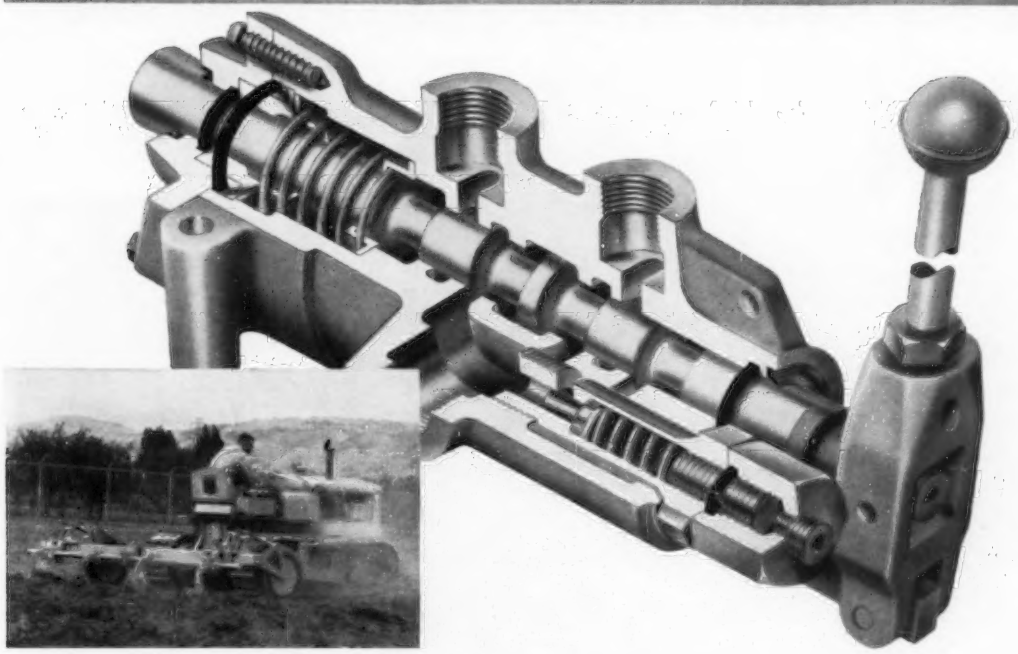
Speaking on "New Concepts of National Strength" from a background of more than four years of personal experience in our nation's top level councils on national defense economy, technical defense measures, and manpower problems, Dr. Arthur S. Fleming presented four basic assumptions, namely (1) We are living in an age of peril which will continue for many years, (2) Russia has not abandoned its purpose to communize the world, (3) The soviets will make the most of every opportunity to invoke cold war, (4) We must keep ourselves in a position to deal with communism from a position of strength. He pointed to a dynamic, expanding civilian economy as our most important mobilization base.

A session on new concepts in professional development dealt with the changing viewpoint and constructive measures used by employers of engineers to stimulate and encourage their engineers to continued professional progress.

At the closing luncheon the speaker on new concepts in conservation of human resources called for increased attention to the encouragement of scientific curiosity in our young people. By way of correcting a popular illusion that the United States has recently lost first place in science, he said it has never been in first place in basic science.

Now that the United States has launched an earth satellite, this might be misinterpreted by the public as evidence that we have solved our major technical manpower problems. The engineering profession does not think so. It has scheduled an eleventh College-Industry Conference to be held next year at Houston, Texas.

NATIONAL OIL SEAL LOGBOOK



Use of O-rings as moving seal in heavy duty bulldozer control valve

1,500 psi variation without backup rings. Intermittent operation plus long periods of inactivity. Extreme external dust and dirt conditions. Irregular and unpredictable field servicing. Fluid oil temperatures reaching 180°F. Climatic temperature extremes from —30° to +120°F. Life expectancy is required to be that of the tractor.

Above are the rugged operating conditions faced and met by National industrial O-rings in the new Be-Ge Model SU-1200F bulldozer blade control valve. A total of four rings are employed in each unit; two in a moving shaft application and two as static seals.

Be-Ge reports no leakage or ring failure on hundreds of heavy duty applications involving Oliver, Caterpillar, International Harvester and other crawler tractor installations.

National offers a complete line of industrial O-rings, plus many exclusive compounds. Special compounding is also available to meet unusual conditions.

For complete information on National O-Rings, or for skilled O-ring engineering service, call your nearest National Seal engineer. In major cities nationwide. See the Yellow Pages, under "Oil Seals".

Syntech® Oil Seals

Syntech oil seals, developed by and offered exclusively by National, are widely used synthetic rubber seals for applications where temperatures reach 250°F, speeds reach 3,600 FPM, and total indicator runout is as high as .030. Basic 50,000 series Syntech (illustrated) employs a tough, accurately manufactured steel outer case, precision-tensioned spring and accurately molded and trimmed Syntech sealing lip.

Micro-Torc Oil Seals

Micro-torc oil seals, pioneered by National, are sturdy, dependable leather seals. Special elastomer coating on *surface* of chrome re-tanned leather sealing lip prevents seepage of oil. Yet inner body of sealing lip retains natural porosity to "store" lubricant against accidental periods of starvation. Inherent lubricity of elastomer coating produces a lower torque, longer lasting, economical oil seal. Available in a wide variety of types and sizes.

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4624

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Every day . . . in all these ways . . .

speed through more work with TA

You'll save minutes and movements on every turn when you cultivate with TA. Just pull the TA lever to slow down 30% for safer, full-power turns, then release the TA lever to resume top cultivating speed.

Pull TA lever to take bunchy windrows in stride. TA reduces forward travel instantly, yet keeps pto machines at full-rated rpm to handle sudden overloads. There's no clutch slippage, no loss of efficiency, no fuel waste.

Name any job—plowing, planting, cultivating, baling, hauling! You can do it faster, easier, at lower cost with *exclusive* IH Torque Amplifier drive on a new Farmall® or International® tractor.

TA is the big difference that puts IH tractors in a class by themselves! Ten speeds forward—two in each gear—match every job, hurry all work. TA gives you instant pull-power increase of up to 45% that keeps you going *non-stop* when others must shift.

From winter chores through fall harvest, Torque Amplifier drive puts IH tractor power to better use.

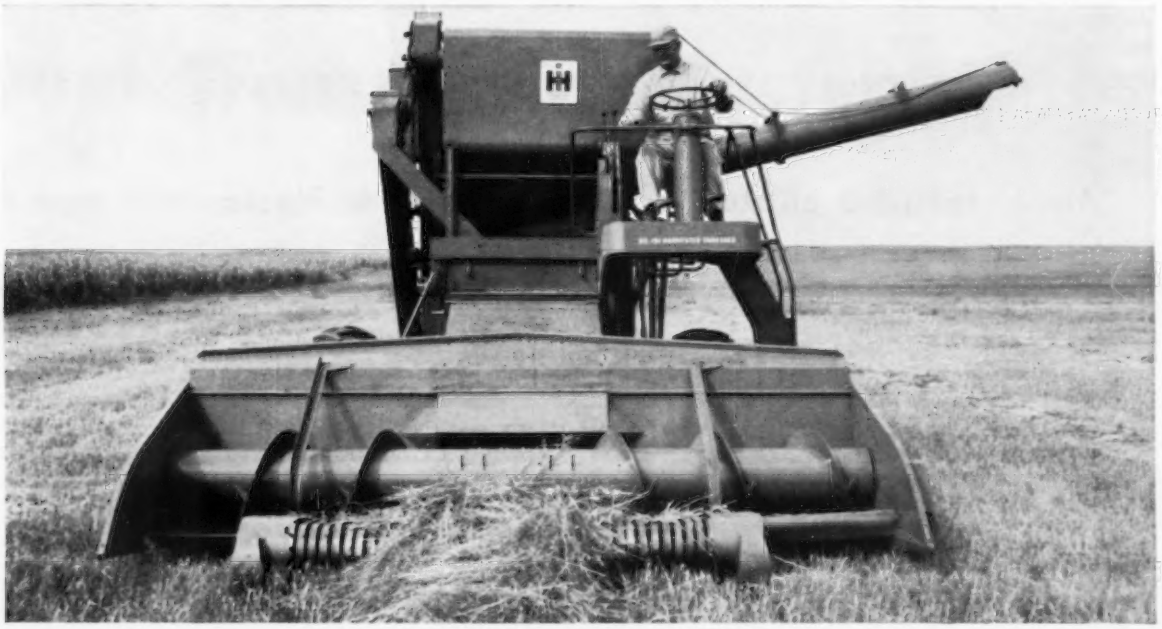
See why you're a BIGGER MAN on a new IH TRACTOR!

Your IH dealer will gladly demonstrate Torque-Amplifier, Traction-Control Fast-Hitch, Hydra-Touch hydraulics, and all other IH features.

SEE YOUR INTERNATIONAL HARVESTER DEALER

International Harvester Products *pay for themselves in use*—Farm Tractors and Equipment . . . Twine . . . Commercial Wheel Tractors . . . Motor Trucks . . . Construction Equipment—General Office, Chicago 1, Illinois.

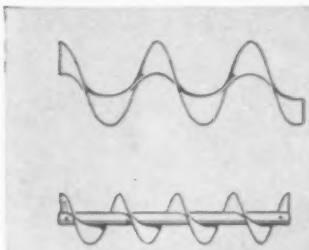
How LINK-BELT makes it easy to **work augers into your design**



INTERNATIONAL HARVESTER COMPANY employs Link-Belt screw conveyors throughout their No. 151 Harvester Thresher for gathering, conveying, elevating and distributing the harvest.

WHERE augers are a vital part of any equipment, here's the sure way to better equipment design. Link-Belt augers are available in a full range of diameters, gauges and pitches . . . in any suitable metal to meet your exacting requirements. They're simple and compact, accurately made to insure dependable operation.

For any design problem involving augers ask the Link-Belt office near you for engineering assistance.



SELECTED FLIGHTING for all your auger needs. Helicoid, sectional or a range of other types are available in the metal and finish best suited for your design.

SIMPLICITY OF CONSTRUCTION and sturdy design of Link-Belt augers provide dependable, efficient operation on your machine. One basic assembly — no other moving parts to break down.

YOUR CHOICE OF METALS answers your requirements for handling corrosive or abrasive materials. And Link-Belt uses only specially selected steels.

ENGINEERING SERVICES. Our auger specialists will help to analyze your special needs . . . integrate all elements of your design for overall system efficiency.

ALL COMPONENTS — conveyor screws, collars, couplings, hangers, troughs, trough ends, flanges, drives—are available for every design.

LINK-BELT

FARM MACHINE AUGERS

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DAYTON DOUBLE COG-BELT*

Infinite choice of speeds — from 1½ to 14¾ mph —

A dual transmission system permits fast, accurate speed changes to suit any ground or crop condition encountered by the Gleaner Baldwin combine.

Stopping, starting, and speed range changes are made through the automotive-type three-speed and reverse transmission while a variable speed sheave remains unchanged. Once the range is selected, a hydraulic control varies the speed infinitely between 1½ to 3¼ mph in low, 3 to 6½ mph in intermediate, and 6½ to 14¾ mph in high gear.

At the heart of this system is a Dayton Double Cog-Belt* which transmits power from the engine — mounted high in the combine — to the hydraulically controlled variable speed sheave.

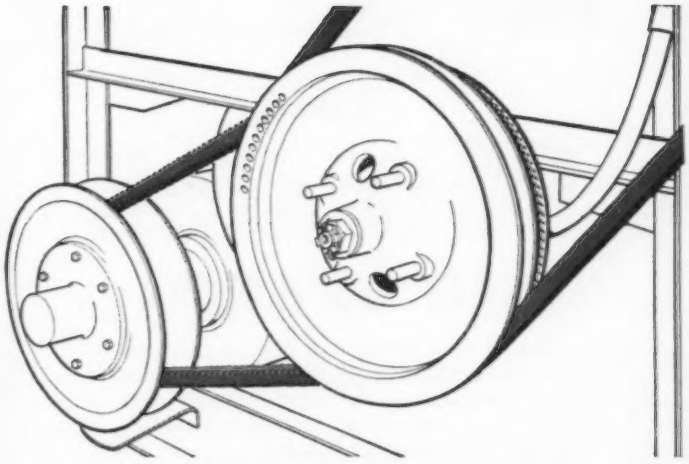
Dayton recommended their Double Cog-Belt because (1) the die-cut raw edges would transmit the torque from the engine without slipping; (2) it resists squashing under heavy loads; and (3) it has the high degree of flexibility required when operating with small pitch diameters at

Drives Allis Chalmers Dual Transmission System

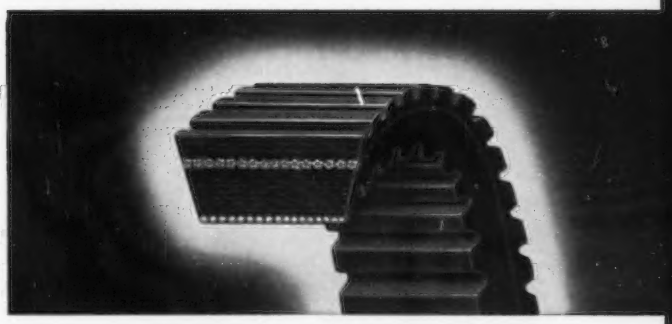
means faster combining with this Gleaner Baldwin Unit

input speeds of nearly 2,000 r.p.m. In extensive field tests, the Dayton Double Cog-Belt met every requirement and was accepted as production material.

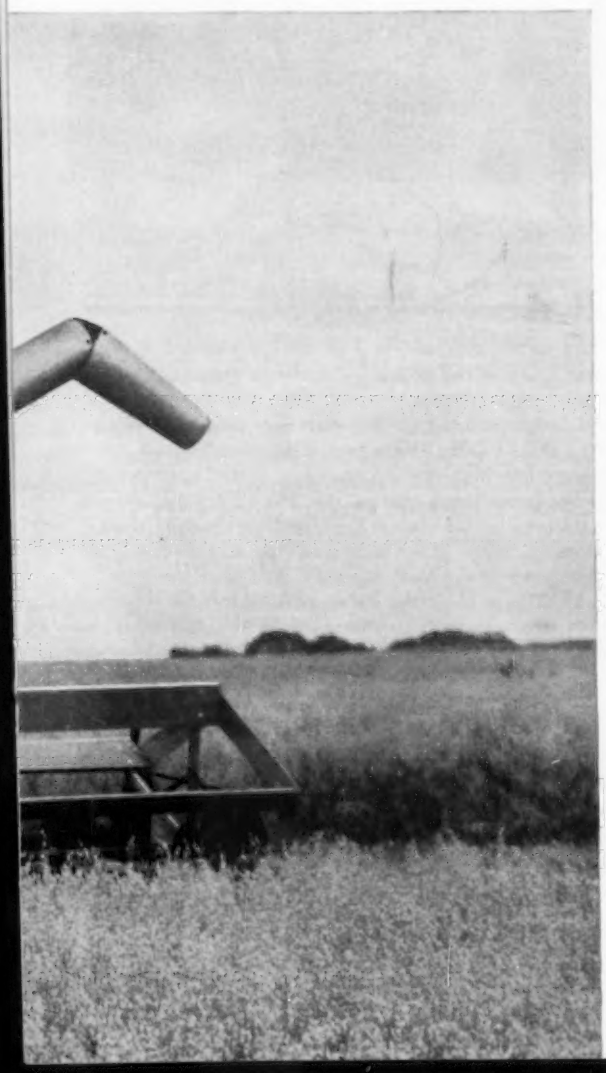
Next time you have a power transmission problem, consult a Dayton Agricultural Engineer. He can recommend a suitable V-Belt from Dayton's complete line or engineer a special belt for your exact requirements. To contact him, write Dayton Rubber Company, Agricultural O.E.M. Division, Dayton, Ohio.



Dayton Double Cog-Belts are the lowest cost, simplest, and most easily maintained form of variable speed transmission.



Especially designed for use with small diameter sheaves, exclusive Dayton Double Cog-Belts have die-cut edges for positive gripping and extreme cross-wise rigidity to prevent squashing and distortion.



*T. M. © D. R. 1958

Dayton Rubber

First in Agricultural V-Belts

Agricultural Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis

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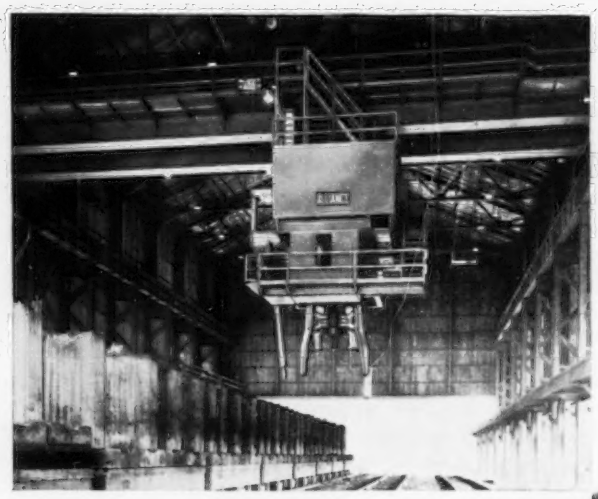

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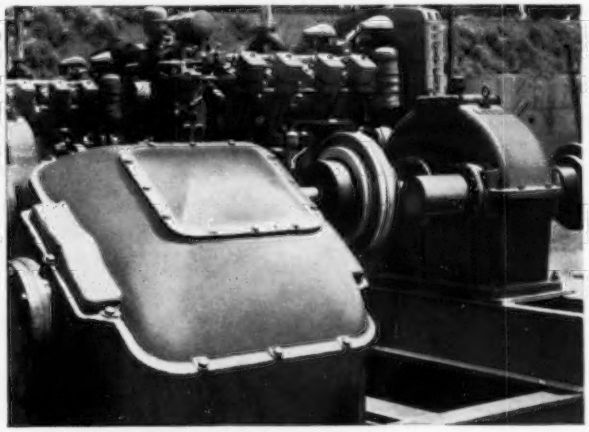
the more you need HYATTS . . . because you get more sheer load-carrying capacity with straight cylindrical roller bearings than with any other type. HYATTS give outstanding service in this 400-ton stripper crane.

THE HIGHER THE SPEED...

the more you need HYATTS . . . because carburized races, electronic control of eccentricity and internal clearances, and uncompromising final inspections assure smoother performance in speed reducers like this one.



THE MORE YOU NEED *Cylindrical* HY-ROLL BEARINGS

Loads are growing heavier, speeds are growing higher in many types of machinery today—and at the same time designers must often *reduce* overall size. Here's where HYATT Hy-Rolls have it all over limited-capacity bearings—especially when you eliminate either inner or outer races of separable HYATTS and operate the rollers directly on the hardened and ground shafts or housing bores. It's a smart way to save added space without sacrificing load capacity. Ask your nearest HYATT Sales Engineer for recommendations.
Hyatt Bearings Division, General Motors Corporation, Harrison, N.J.; Pittsburgh; Detroit; Chicago; and Oakland, California.

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908–1958 GM FORWARD FROM FIFTY

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

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Report to Readers . . .

ENGINEERS IN AGREEMENT ON NEW 1000-RPM POWER TAKE-OFF DRIVE

The engineers of the farm equipment industry have to their credit another significant accomplishment. As a group and with the backing of their respective company managements, they have recently reached agreement on a proposed new standard for the 1,000-rpm power take-off drive for farm tractors. (An announcement of this action and a review of the proposed standard appear elsewhere in this issue.) . . . . The original PTO standard, for the 540-rpm drive, was adopted and given industry-wide approval more than thirty years ago. It proved to be a truly great achievement, for without it the problem of operating a machine of one make through the power take-off drive of a tractor of another make would have resulted in general confusion worse confounded, along with higher operating costs. . . . . The new 1,000-rpm drive will help to set an even faster pace in power-farming development. It will make possible some reductions in manufacturing costs (aside from some higher initial costs to put necessary changes into effect) and several improvements in operating efficiency. Also greater safety is made possible by improved power shaft shielding.

GOAL OF 90 PERCENT EXCEEDED IN MECHANICAL HARVESTING OF GRAPES

Grape harvesting has been absorbing a lion's share of farm hand labor in California, so a research team composed of four engineers and a viticulturist decided to challenge this "monopoly," and wound up by actually exceeding the goal it set of a 90 percent harvest yield in commercial vineyards by mechanical means. (The normal hand harvest yield is about 95 percent.) . . . . The research program that produced this brilliant achievement was set up in 1953 in the agricultural engineering department of the University of California at Davis. The main features of the project were to develop a unique trellising-training system for the grapevines and a mechanical harvester. . . . . The story of this remarkable development was told by Lloyd H. Lamouria at the ASAE winter meeting in December and will appear in a subsequent issue of this journal.

"BUBBLE BUILDINGS" PRESENT NEW CHALLENGE TO ENGINEERS

Though they do appear like huge bubbles on the landscape, the more precise, descriptive term for them is "pneumatic structures." Air-supported buildings have been under study for some time, and at the ASAE winter meeting in December the subject was presented in some detail by L. W. McConnell. He said pneumatic structures are possible and practicable because a variety of relatively durable, inexpensive fabric and plastic membranes are now commercially available, as are also dependable sources of electric power to maintain the pressure differential these structures require. He also pointed to the possibility of using pneumatic structures as temporary or disposable farm buildings to save housing and materials-handling costs. . . . . In summary the speaker stated that pneumatic structures offer a new low-cost approach to some agricultural housing needs, chiefly because of the advantage of low construction and maintenance costs. Obviously the disadvantages of this type of structure are many and varied, and for that reason much practical designing will need to precede any appreciable development of this potential market.

FOUR-WAGON CENTRAL UNIT DRIES HAY AT LESS COST

Engineers at the New Jersey Agricultural Experiment Station have come up with a new design for a wagon hay-drying unit which they believe will make possible (1) automatic control of fan and heaters and (2) lower installation cost than for a 4-wagon-in-line unit. . . . . Designed in the form of a Greek cross, the new unit consists of a central shed which houses two heaters, a large fan and suitable dampers for drying. On the four sides of the shed are located one-wagon units, each consisting of a plenum roof and drop canvas. Canvas ducts

connect the plenum chambers to the central shed. . . . . Heated air is forced down through each loaded wagon. Skirts located at the bottom of each wagon and connected with four recirculation dampers on the side of the central shed provide for recirculation of the air. Each wagon can be treated independently of the others. This coming season the engineers aim to obtain accurate cost figures and to develop automatic controls for operating the fan and heaters . . . . In their efforts to develop ways and means of producing top-quality hay over the past two decades, the engineers have made gratifying progress. It is now possible to reduce the chances of producing poor hay to a slim margin.

PROBLEM OF WATER LOSSES FROM SURFACE IRRIGATION — Roughly one-third of all water diverted for surface irrigation is lost. So reported C. W. Lauritzen at the ASAE winter meeting in December. This water loss is primarily from seepage, somewhere between the points of diversion and application, and includes both diversion canals on irrigation projects and farm reservoirs for accumulating and storing irrigation water. . . . . With increasing general concern over the threat of serious water shortages here and there, greater attention in the future will most certainly be given to ways and means of reducing irrigation water losses. One of the most important needs is for lower-cost canal and reservoir linings. In studies reported by Lauritzen, a burlap-asphalt laminate showed top performance among the materials specimens tested, but, as this researcher indicated, the search will continue. What would appear to come nearest to meeting practical and economical requirements deemed essential by engineers is a low-cost exposed membrane lining. In addition to the burlap-asphalt laminate, since the polyethylene and vinyl plastic films are being widely used in agriculture, every reasonable effort will likely be made to develop their suitability as canal and reservoir linings.

PRESERVATIVE TREATMENT OF WOOD FOR FARM STRUCTURES PAYS OFF — Wood in some form as a structural material will be very much in the farm buildings picture for a long, long time despite the mounting pressure of competition from other materials. The reason for this is due to the superiority of wood in so many applications. But to maintain its competitive position, increasing use will have to be made of preservative treatment for wood structures to make them last several times longer. J. D. Blew, Jr., of the USDA Forest Service, made an excellent contribution to this subject at the last ASAE winter meeting.

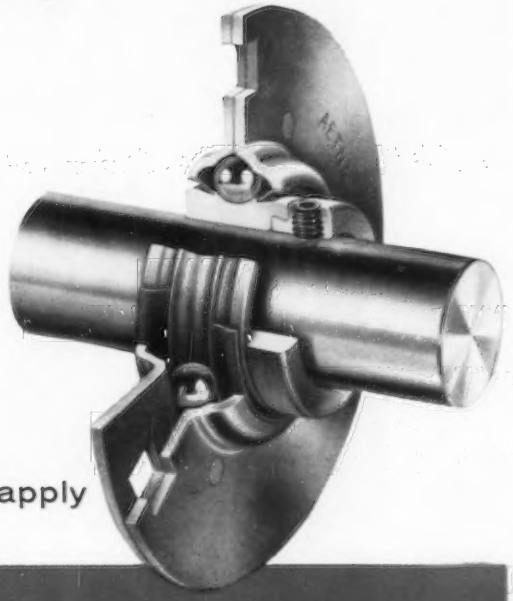
TEACHER SHORTAGE LOOMS LARGE IN THE PROBLEM OF TRAINING MORE ENGINEERS — What could well prove to be the straw that will break the proverbial camel's back, in the concerted drive to train more scientists and engineers, is the shortage of qualified teachers. Such a warning, in a recent report of the Research Division of the National Education Association on teacher supply and demand in colleges and universities, is stated in these words: "These institutions of higher education . . . are already suffering a serious deterioration in the quality of their instructional staffs . . . This fact stands out: The total number of persons with high-level skills and comprehensive preparation does not equal the present demand. . . . Right now the total resources of the colleges and universities are not equal to the task which only they can perform. If they continue to be priced out of the market, . . . the quality of their educational service will deteriorate at the very moment it should be further strengthened. . . . This means second-rate education for a larger and larger number of our youth." . . . The obvious solution to such a situation is to encourage more new graduates to continue with graduate study and to enter the teaching profession. Real progress will be made in this direction as the dignity of the profession, along with a higher level of reward, is nationally recognized and supported by public demand.

NOW... more manufacturers can afford to put more ball bearing efficiency to work in more places

Aetna

ADAPTER BEARING

Economical to buy . . . economical to apply

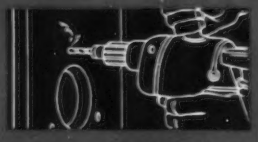


Equipment manufacturers who must stretch bearing dollars in order to build to a price need look no further than this Aetna Adapter bearing —the completely *PACKAGED* ball bearing unit that brings low-cost, anti-friction efficiency within the range of all light-duty slow-speed equipment.

Designed and built-to-be-installed-and-forgotten, this permanently lubricated, sealed-for-life Adapter bearing requires no re-lubrication, no maintenance of any kind. It combines self-aligning bearing, seals, mounting flange and locking collar in a single, compact, factory-assembled *PACKAGE* that mounts easily, quickly, wherever shafts can be supported, including mounting on sheet metal or any semi-rigid structural member. Available in 8 standard shaft sizes, ½" to 1¼". Send for catalog AG-57 or call in the local Aetna representative listed in the yellow pages. Aetna Ball & Roller Bearing Co., Division of Parkersburg-Aetna Corp., 4600 Schubert Ave., Chicago 39, Ill.

EASY, QUICK 3-STEP MOUNTING

1



Drill (or punch) 2 bolt holes in shaft supporting member.

2

Place Adapter bearing in position, insert bolts and tighten nuts.

3

Install shaft, twist locking collar, tighten set screw.

Aetna ANTI-FRICTION CONSULTANT TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

For more facts circle No. 71 on reply card

Under operating pressures bushing heats and releases stored lubricant which is reabsorbed by bushing when chain is idle. Cycle continues for life of chain.

LET THE DUST FLY

WHITNEY SELF-LUBE AG CHAIN

keeps farm equipment continuously operating without chain maintenance.

Under conditions of extreme dust or mud, it will outlast regular chain by as much as five to one.

SECRET? *Exclusive*, high strength Sintered Steel Chain Bushings, *pre-lubricated* for life . . . Whitney engineered and completely proven by long hours of extensive field service.

Whitney's Sintered Bushings are designed to provide film-oiling from within their cores in ratio to operating loads. The tougher the usage, the more lubrication to vital chain parts.

And Whitney Self-Lube Ag Chain is self-cleaning . . . controlled clearances eliminate trapping of ruinous abrasive materials and prevent "freezing" of chain joints. It's "the chain that maintains itself!"

LIMITED? No, Whitney Self-Lube Ag Chain is completely interchangeable with A.S.A. Double Pitch Roller Chains. They are precision made of premium materials and engineered for all types of farm machinery.

Your customers profit by the time and money saving benefits of Whitney Self-Lube Ag Chain. Whitney nation-wide consultant engineering service is promptly available to assist in determining the chain best suited to your requirements. If you want *results* specify WHITNEY CHAIN.

Write for free technical brochures.

CREATORS OF SELF-LUBE AG CHAIN

Whitney

CHAIN COMPANY

318 HAMILTON ST., HARTFORD 2, CONN.

SELF-LUBRICATING • SELF-CLEANING • HIGH STRENGTH • COMPLETELY INTERCHANGEABLE

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

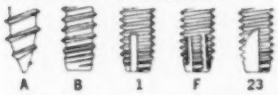
Technical-ities

By John S. Davey

How to select tapping screws

1. Use *thread forming* screw Type A, B or C when material is ductile enough to stand deforming action of screw. If not, use *thread cutting* type.

2. Type A is used with pierced hole for starting; and where an exposed point doesn't matter. All other cases use B, C, or other blunt screws in drilled holes.



3. When load is no factor, metal gauge determines diameter of screw. Pick a thread pitch which gives at least a full thread engagement.

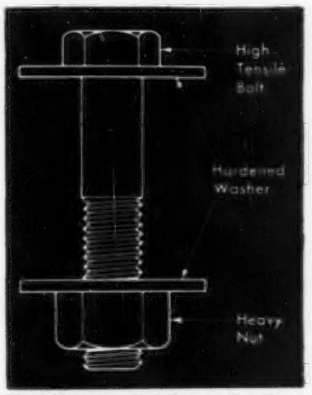
FOR EXAMPLE: Metal .062" thick suggests use of #7 Type A or #10 Type B (both have 16 threads/inch).

$$\text{PITCH} = \frac{1.00}{16} = .0625"$$

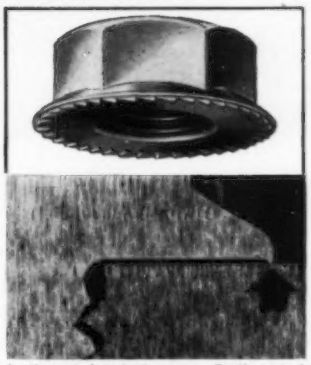
4. When you do have loads to sustain, you must consider required holding power. If metal thickness doesn't allow ample thread engagement (so that threads strip), use more smaller diameter screws. They engage more threads. Limiting factors: the screw's torsional strength, and the effort to drive it.

5. If, due to material thickness, screws fail by torsion or drive too hard, select cutting screws (1, F, or 23). For hard ductile materials, the Type 1 is best; for soft, friable materials, the Type 23.

Two basic ways to keep fasteners tight



RB&W high strength bolts permit optimum tightening without crushing surface when used with hardened washer.



Section of Spin-Lock screw. Teeth embed only with proper tightening. Same feature available in nuts.

Fasteners that stay tight keep joints strong. Resistance to loosening depends largely upon: (1) The inherent "locking" ability, (2) The man with the wrench.

HIGH PRELOADING

With rigid type joints, one of the best "locking" fasteners is a standard RB&W high strength bolt or cap screw . . . *torqued up close to its yield strength.* It locks by its own internal residual tension.

High tension not only keeps it permanently tight, but also prevents fatigue, assures optimum load capacity and safety.

INTEGRAL LOCKING DEVICE

Suppose the design of fastened members can't take full advantage of such preloading? Then a lock is needed, such as that furnished by RB&W Spin-Lock® screws and nuts. Ratchet-action teeth bite into seat; require 20% extra torque to loosen.

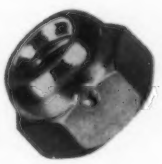
Note that Spin-Lock fasteners seat solidly before locking. The installer can't be deceived. He *has* to tighten properly before feeling resistance.

In both cases above, *positive* tightening assures positive fastening.

Send for Bulletin on Spin-Lock fasteners, or call your local RB&W Fastener Man. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

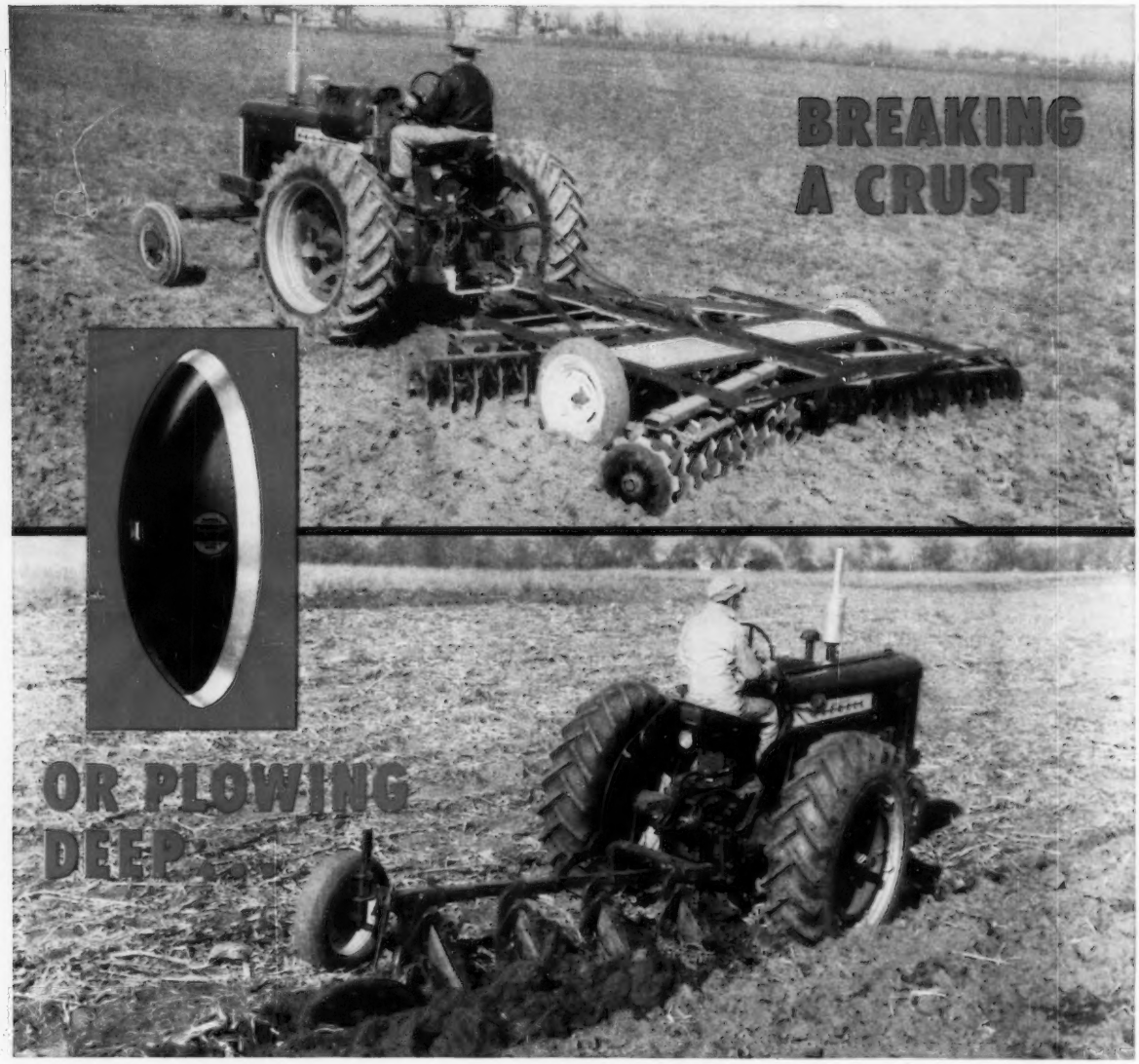
Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Staked acorn nuts lock securely



Staking opposite sides of these RB&W acorn nuts deforms threads for a positive grip. It also puts middle of nut slightly out-of-round, for a spring tension locking effect. They're designed for applications such as outdoor furniture, where anchoring fasteners is more important than solid seating. Available in aluminum, steel, silicon bronze.

These all-metal nuts can also be furnished in regular double chamfered style. Since they lock with their middle threads, they can be turned onto screw from *either* side.



It Goes Better and Faster with Ingersoll Discs

You see a lot of International Harvester equipment on the nation's farms. Equipment like the McCormick No. 37 Disc Harrow and "Fast-Hitch" Disc Plow shown above. They're both equipped with sharp, rugged Ingersoll discs and they're built to do a variety of tough tillage jobs and take the punishment and fast pace of modern farming.

In Ingersoll discs and coulter blades, farm equipment manufacturers get the same high quality they build into their implements. That's why the leaders *all* use Ingersoll discs as original equipment and also supply them as replacements.

Only outstanding performance can account for the wide acceptance of Ingersoll discs. They're the only discs made of TEM-CROSS® steel—the special tillage steel that's cross-rolled for greater resistance to impact, splitting and curling. They're heat-treated, too, and tempered by an exclusive Ingersoll process to prevent warping, withstand abrasion and hold a keen edge longer.

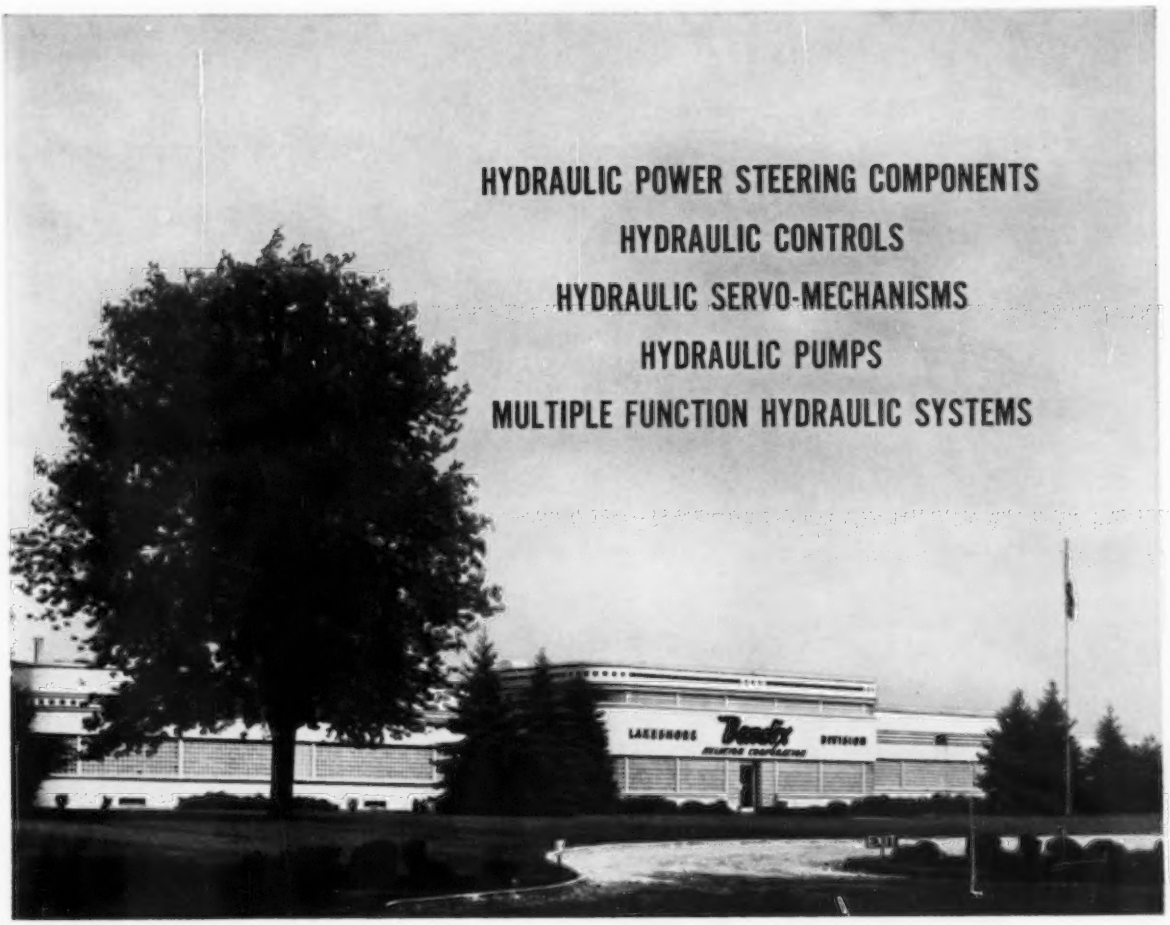
Install Ingersoll discs whenever you make replacements. You can order them direct from your implement manufacturer and rest assured you've given your customers the best.

INGERSOLL PRODUCTS DIVISION
Borg-Warner Corporation, Chicago 43, Illinois

SPECIALISTS IN TILLAGE STEELS • WORLD'S LARGEST MANUFACTURER OF DISCS

EXPORT SALES: Borg-Warner International, 36 S. Wabash, Chicago 3, Illinois

THE ONLY MANUFACTURER OF DURA-DISC — THE STEEL THAT IS THE ECONOMICAL REPLACEMENT FOR HIGH COST ALLOYS



IT'S BENDIX-LAKESHORE FOR COMPLETE HYDRAULIC ENGINEERING AND MANUFACTURING

—Automotive or Agricultural—

Whatever your needs in agricultural or automotive hydraulic components, you'll be wise to look first to Bendix-Lakeshore. One of the newest and most modern divisions of the great Bendix Aviation Corporation, Bendix-Lakeshore is geared to provide you with fast, efficient service on any product, whether it's designed by our own skilled engineering staff or produced here from your design.

Despite being a comparatively new division, Lakeshore is old in experience. Backed by the great resources of Bendix Aviation Corporation, it is staffed in large part by engineers who have spent an aggregate of hundreds of years in hydraulic research and design, both with Bendix* and other firms. Solid engineering research and extensive testing are standard procedure with us. When you order hydraulic components from Bendix-Lakeshore, you get the benefit of complete engineering facilities.

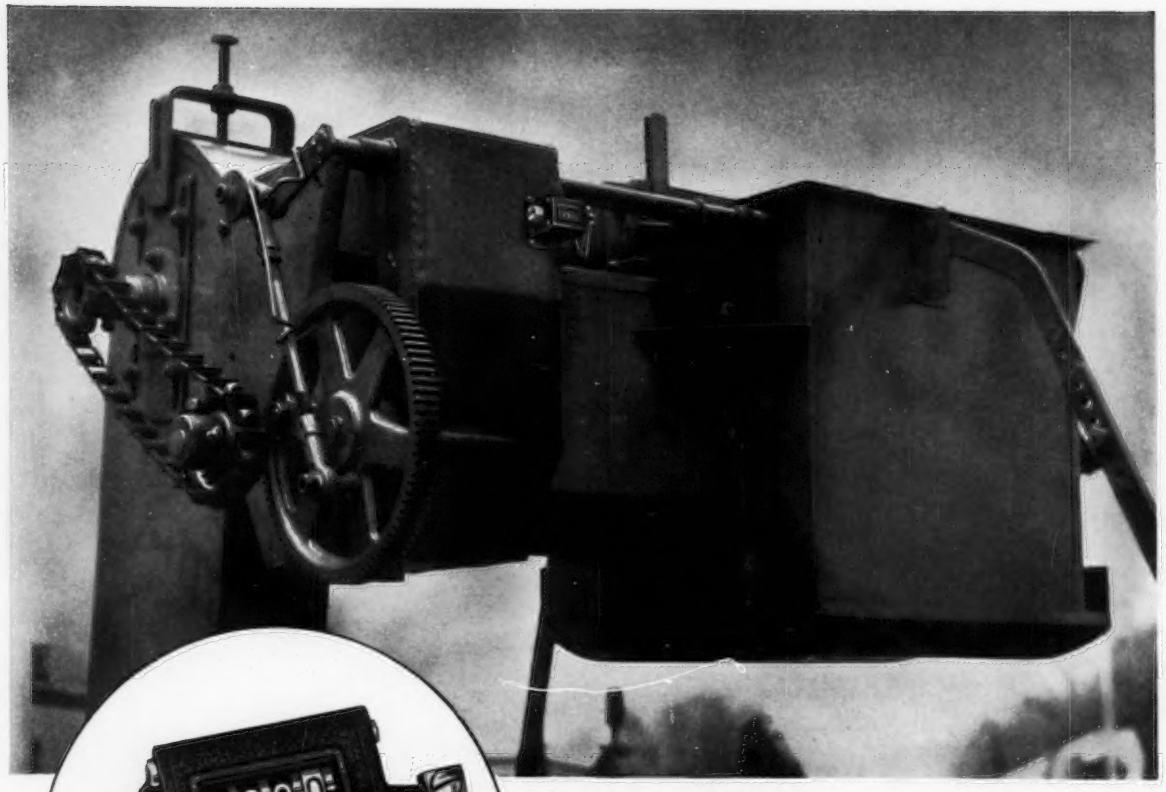
Bendix-Lakeshore's reputation for quality in the field of hydraulic components has helped us acquire, in the space of five years, a list of customers whose standards are beyond question. Remember, if you have a problem in engineering or manufacturing of automotive or agricultural hydraulic components, it will pay you to investigate the facilities and abilities of Bendix-Lakeshore in these specialized fields.

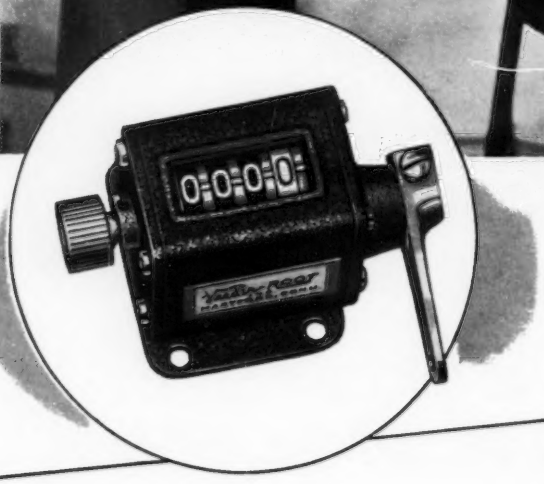
*TRADEMARK

Lakeshore Division
St. Joseph, Michigan

Bendix
AVIATION CORPORATION

For more facts circle No. 76 on reply card





Combine Owners:

Here's how a built-in

VEEDER-ROOT COUNTER

helps you 4 ways!

1. **IN CUSTOM COMBINING.**
   Counts every bushel right in the field.
2. **IN SHARING THE HARVEST.**
   The accurate tally tells the yield exactly, prevents arguments between landlord and tenant.
3. **IN FARM STORAGE.**
   Permits storing or dividing grain in the correct amounts.
4. **IN YIELD VERIFICATION.**
   Helps check the use of fertilizer or the advantages of summer fallow.

For accurate counting (and cost-controlling) down on the farm, Veeder-Root makes a complete line of counters which are built into tractors, hay balers, grain drills and combines. *Get the facts* whether you make, sell, buy or use farm equipment. Write for bulletin.

VEEDER-ROOT INC.

"The Name That Counts"

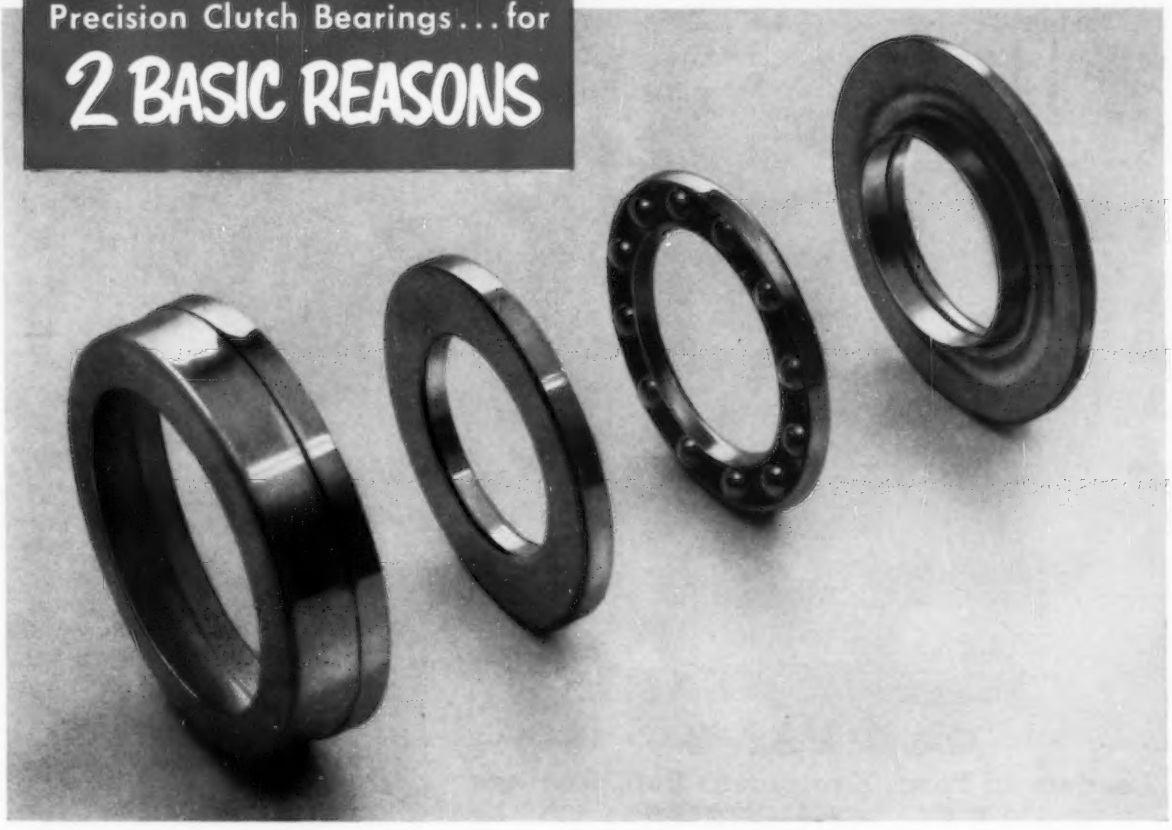
HARTFORD 2, CONNECTICUT

549 WASHINGTON BLVD., CHICAGO 6 • Tel: State 2-6283

For more facts circle No. 65 on reply card

Engineers Specify BCA
Precision Clutch Bearings . . . for

2 BASIC REASONS



Endurance . . .

BCA precision clutch bearings exceed engineers' most severe test standards . . . over 70,000 declutchings at speeds corresponding to more than 60 mph. Performance like that results from such **BCA** construction features as . . . high carbon chrome balls . . . carburized and precision ground steel washers . . . single piece U-section retainer, designed to trap grease between the rotating members . . . labyrinth sealed with rigged pressed steel housing and special bronze ferrule . . . packed with a stable, high temperature grease.

Economy . . .

BCA precision clutch bearings offer real dollar savings because of . . .

- low initial cost
- easy installation
- trouble free service.

BCA precision clutch release bearings are backed by 60 years of ball bearing design and manufacturing experience—for all kinds of vehicle applications. Specify BCA clutch bearings for real endurance and economy. Bearings Company of America Division, Federal - Mogul - Bower Bearings, Inc., Lancaster, Pa.

Call BCA Engineers on matters pertaining to bearing problems.

BCA

BEARINGS COMPANY OF AMERICA
DIVISION OF
Federal-Mogul-Bower Bearings, Inc.

For more facts circle No. 73 on reply card

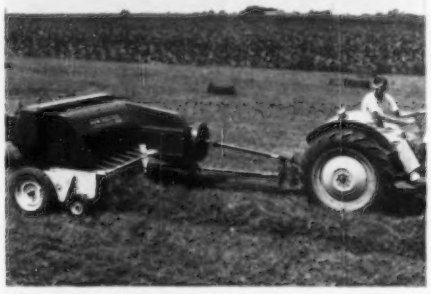
15 YEARS

NEW HOLLAND MACHINE COMPANY

Leaders in Grassland Farm Machinery, looks to . . .

New Holland Model 800 Forage Harvester chops up grass, sorghum, or corn at a rate of up to 45 tons an hour.

New Holland Model 440 Mower Crusher cuts and conditions hay for faster curing in one trip around the field.



New Holland "Hayliner" 68 Baler is built to do any baling job on the family farm.

The FAFNIR BEARING COMPANY

Leaders in Farm Equipment Ball Bearings

Ask today's farmer what he looks for when he invests in farm machinery and chances are he'll mention anti-friction bearings. He knows they give smooth, power-saving performance and cut down maintenance requirements.

Fafnir's wide experience with farm implement bearing applications is a big reason why New Holland has worked with Fafnir for more than 15 years.

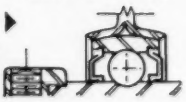
Just as Fafnir pioneered the development of ball bearing units such as Flangettes and bearings with contact seals for farm equipment, so New Holland has pioneered the use of anti-friction bearings in grassland farm machinery. The results are . . . simplicity of design, lower costs, longer life, and carefree operation.

Fafnir's effective solutions to bearing problems have helped many leading manufacturers modernize the design and performance of farm implements. Chances are, the right solution to your bearing problem is available at Fafnir. Write The Fafnir Bearing Company, New Britain, Connecticut.

Fafnir Flangettes — "Economy Packages" for Farm Equipment

Extended Inner Ring and contact-type Plya-Seals in this Flangette provide ample shaft support and positive protection against contaminants. It is prelubricated at the factory . . . grease is permanently sealed in. Designed for light duty.

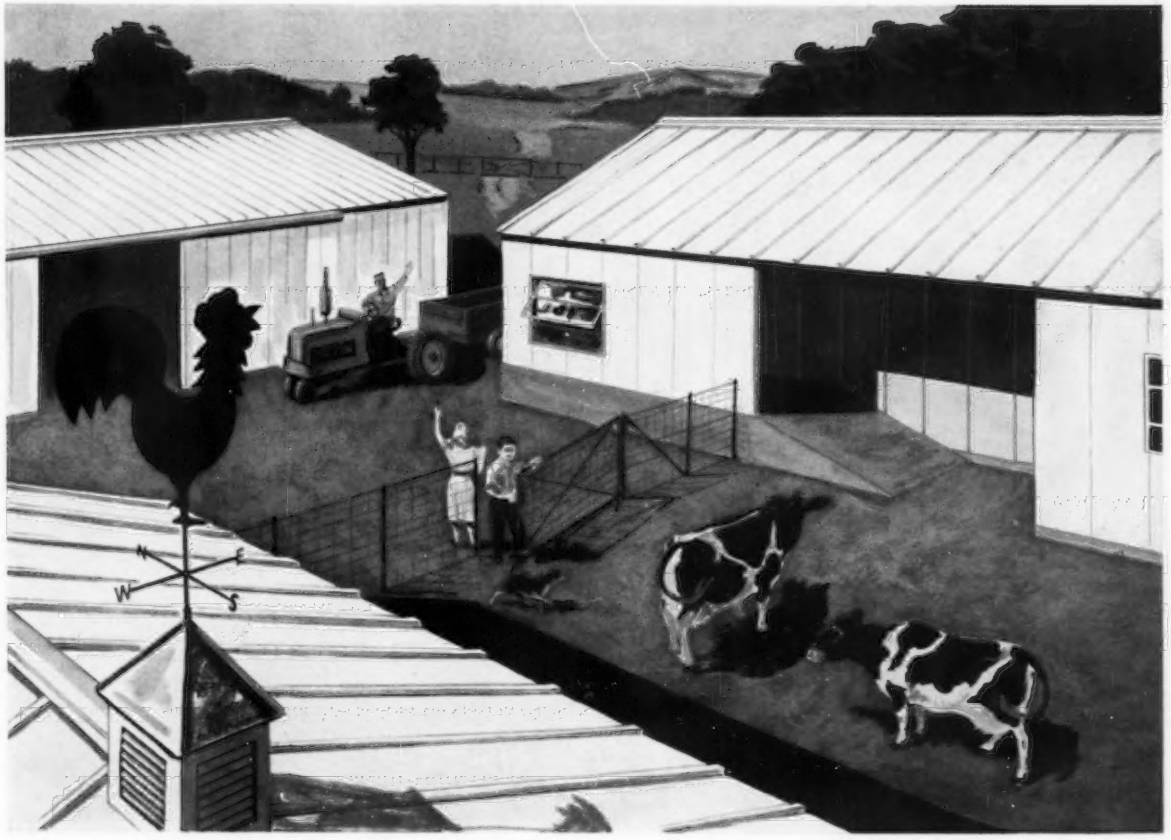
Mechani-Seals, slinger-type, and Wide Inner Ring construction provide a combination of frictionless operation, extra-rigid shaft support, and effective seal in this versatile Flangette. It is prelubricated, and equipped with Fafnir-originated self-locking collar.



FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA



Buildings made of ALUMINIZED STEEL

Last Longer, Stay Cooler, Cost Less

When farm buildings are made of Armco ALUMINIZED STEEL Type 2, you gain five big advantages:

1. ALUMINIZED STEEL provides outstanding resistance to atmospheric corrosion. Eighteen-year tests with unpainted samples in a mild industrial atmosphere show that the coating on this special hot-dipped aluminum coated steel outlasts commercial galvanized coatings at least three to one.

Reflects Heat

2. ALUMINIZED STEEL Type 2 reflects approximately 80 per cent of radiant heat. Because buildings made of this steel are cooler in summer, livestock production is higher. These buildings are also easier to keep warm in winter.

3. Because this 2-in-1 metal has the high strength of the steel base, buildings resist damage from storms, fire, farm animals, and bumps from farm equipment.

Costs Less

4. Thickness for thickness, ALUMINIZED STEEL costs less than sheet aluminum. Its extra strength usually permits a reduction in gage over aluminum, and it doesn't need painting for corrosion protection. It costs less than commercial galvanized steel plus one field coat of paint.

5. ALUMINIZED STEEL withstands moderate brake- and roll-forming operations.

For complete information on this special aluminum coated steel, write us at the address below for a free copy of our new catalog, "Armco ALUMINIZED STEEL Type 2."

ARMCO STEEL

ARMCO STEEL CORPORATION • 1128 CURTIS STREET, MIDDLETOWN, OHIO
SHEFFIELD DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

For more facts circle No. 77 on reply card

This versatile "Terra-Scoop" is made by Danuser Machine Company, Fulton, Mo., for use with well-known makes of tractors. For maximum strength and minimum dead-weight, Danuser uses two nickel alloy steels in bucket and frame – United States Steel Corp.'s "T-1" and Youngstown Sheet and Tube Co.'s Yoloy "E".

Scoop with ¾ ton bite made light enough for standard tractor

3 Nickel steels scale up its strength...scale down its weight

The "Terra Scoop"®$_1$ has buy appeal to farmers. Designed with emphasis on high-strength, light-weight materials, it's light enough to attach to a standard tractor... strong enough to lift 1500 pounds of soil in one bite.

And that's where nickel alloy steels come in. They give the "Terra-Scoop" all the strength it needs . . . and more ...without increasing weight beyond practical limits.

Bucket shell and frame ends are Yoloy "E"®$_2$. This high strength low alloy nickel-copper steel has a typical tensile strength of 70,000 psi., a yield strength of 50,000 psi.

Bucket ends are "T-1"®$_3$, a weldable, alloy steel containing nickel, heat treated to provide three times the yield strength of carbon steel. Both bucket shell and bucket ends need be only ¼-inch thick. And that means a big weight saving, bigger payloads at lower cost!

Scarifier teeth of the "Terra-Scoop" are AISI 8640 nickel-chromium-molybdenum steel heat treated for a top-notch combination of wear resistance and toughness, to withstand shock and abrasion.

And here's another plus: Both Yoloy "E" and "T-1" steels show excellent resistance to abrasion and atmospheric corrosion. These properties have added years of life to the "Terra-Scoop".

Informative handbook for designers and manufacturers

If your problem is designing, building or selling better, more efficient farm equipment, you'll be interested in seeing what nickel alloy steels are doing for others . . . what they can do for you. Write Inco today for useful 32-page handbook, "Nickel-Containing Materials in Tractors and Farm Implements."

®1 Registered trademark of Danuser Machine Co.
®2 Registered trademark of Youngstown Sheet & Tube Co.
®3 Registered trademark of the United States Steel Corp.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL
NICKEL ALLOYS PERFORM BETTER LONGER

Protected watershed near Weatherford, Texas, saved millions in farms, crops, highways, homes, businesses, soil — and perhaps even human life.

Protected watersheds weathered the floods with flying colors

Ask any Texan in the East Fork Laterals Watershed project south of Dallas what he thinks about watershed protection. Chances are he'll point to a bridge still sound as ever, despite the violent floods of last April and May – or a flat piece of alfalfa that is free from flood damage – or a reservoir with little evidence of silting – and tell you that *without* watershed protection, all these *and more* would be seriously damaged. Yet East Fork Laterals weathered 11.91" of rain in seven days – 5" of which fell during one 6-hour storm – and came through with minimum flood and erosion damage.

Meanwhile, just a couple of counties away, Lampasas – without a watershed protection program – still fights off the crippling effect of the raging Sulphur Creek. Here 5 people drowned, thousands of acres were flooded, 38 homes destroyed – total damage conservatively estimated at $3,700,000. Survey teams report that adequate watershed protection could have held damage to $50,000 or even less.

The story is the same wherever the floods came: when watershed control work was far enough along to be effective, damage was held to a minimum. For example, flood-spawning cloudbursts poured down on the Honey Creek Watershed project near Dallas – on the Cow Bayou Pilot Watershed south of Waco – completed portions of the upper Washita Watershed near Cheyenne, Oklahoma – but they stood the test.

Today, thoroughly convinced of the value of watershed protection, farmers, businessmen and civic-minded Texans are forming watershed districts that will tame the once-in-a-lifetime floods – as well as the smaller floods that occur almost every year.

What about *your* community? Does it have a flood control problem? Is irreplaceable topsoil being lost to a dangerous degree, stripping cropland of fertility, causing serious erosion and cutting gullies?

You can do something about it now, on your farm, by building ponds, dams, terraces, grassed waterways with a CAT* Farm Tractor. Join your neighbors in organizing a watershed district in your community. Your S.C.S. director – farm advisors – community leaders – and your Caterpillar Dealer will help you. Write for free copies of the new booklet "Stop your floods before they start . . ." Address: Dept. AE28, Caterpillar Tractor Co., Peoria, Ill., U.S.A.

Unprotected watersheds in Oklahoma flooded 1,500,000 acres; 35 million dollars property loss.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

FACT OF THE MONTH: *The average annual cost of flood damage in U.S. is $1,200,000,000.*

Caterpillar Tractor Co., Peoria, Illinois

For more facts circle No. 74 on reply card

Preferred

by more engine manufacturers
for original equipment
and replacement service
than any other piston ring!

INTERNATIONAL HARVESTER—one of the leading engine manufacturers using Perfect Circle piston rings for both original equipment and replacement service.

Behind the world-wide preference for Perfect Circle products is a history of more than half a century of research, improved designs, advanced metallurgy, precision manufacturing and engineering assistance to engine manufacturers.

You are invited to share the research facilities and specialized talents of Perfect Circle engineers in achieving a mutual objective...greater economy and improved efficiency in internal combustion engines. Perfect Circle Corporation, Hagerstown, Indiana; The Perfect Circle Co., Ltd., 888 Don Mills Road, Don Mills, Ontario.

Since 1903...partner in progress to the automotive industry

PERFECT CIRCLE PISTON RINGS

Agricultural Engineering

February, 1958
Number 2
Volume 39

James Basselman, *Editor*

New 1000-rpm Power Take-off Standard Approved

IN 1923, the first standard pertaining to the power take-off drive for farm tractors was introduced. At that time, the principal use for the power take-off was to furnish power for driving the rotating parts of grain binders, headers, and, to some extent, mowing machines. The power requirement for these machines was low, usually being in the 2 to 5-hp range. The superior field performance of these early power take-off driven implements resulted in two important developments in farm machinery:

1 Ground-driven implements in general became obsolete.

2 The use of the power take-off was expanded into a large variety of implements, many of which had power requirements far greater and operating characteristics far more exacting than the original grain binders.

The growing acceptance by users of the farm tractor power take-off drive as a means of transmitting rotating power from the tractor to the implement, after these first standardization efforts in the early 1920's, naturally revealed the need for the farm equipment industry to continue its efforts to improve the power take-off drive. The industry's aims in this regard have always been and will continue to be to:

1 Provide for improvements in performance of the implement and tractor combination

2 Provide for safer operation of power-driven farm machinery

3 Anticipate the development of new power-driven agricultural implements and provide for their proper use

4 Establish specifications which will permit any PTO-driven implement which conforms to the standards to be operated successfully by any make of tractor that likewise conforms to the standards.

Since the first standard relating to the farm tractor power take-off was approved in 1923, there have been numerous revisions and additions which have defined pronounced improvements in the power take-off drive, with the result that now both the American Society of Agricultural Engineers and the Society of Automotive Engineers have officially recognized and adopted the following standards and recommendations relating to farm tractor power take-off drives:

1 540-rpm Power Take-off for Farm Tractors

2 Operating Requirements for Power Take-off Drives

3 Definitions and Terminology for Farm Tractor Power Take-off Drives.

In addition to the foregoing items, the American Society of Agricultural Engineers has now approved a new additional standard: 1000-rpm Power Take-off for Farm Tractors. The Society of Automotive Engineers also now has this new standard under review for adoption as an official standard.

In general, with the exception of changes made in the early 1940's, it has been possible to effect many of the desired improvements in the power take-off drive without upsetting interchangeability between "old" and "new" tractors and implements as far as the power take-off was concerned. During this period, however, a number of improvements have been developed which cannot be introduced to the farm market without upsetting this interchangeability between so-called "old" and "new" machines. A sufficient number of these changes have now been combined and incorporated in this new ASAE standard: "1000-rpm Power Take-off for Farm Tractors." (The complete text of the new standard begins on page 86.)

The new 1000-rpm power take-off standard differs from the existing 540-rpm standard in the following respects:

1 The operating speed is increased from 540±10 rpm to 1000±25 rpm.

2 The splined fitting on the tractor power take-off outlet is changed from a 6 straight-sided spline to a 21-tooth involute-shaped splined fitting.

3 The length of the splined section on the tractor power take-off shaft is reduced by 1 in.; the groove in the outside diameter of the shaft is correspondingly relocated, and the $^{21}/_{64}$-in.-diam. retaining hole in the shaft is eliminated.

4 The horizontal distance from the drawbar hitch-pin hole to the end of the tractor power take-off shaft is increased from 14 to 16 in.

5 The vertical distance from the top of the drawbar to the power take-off shaft is reduced from 6 to 15 in. to 6 to 12 in.

6 The horizontal distance from the outside diameter of the tractor tire to the drawbar hitch pin is reduced from 4 in. minimum to 3 in. minimum.

7 The lateral distance from the tractor center line to the power take-off center line is reduced from 3 in. maximum to 1 in. maximum.

When this new power take-off drive is incorporated into new designs of tractors and implements, the following advantages are expected:

1 The 1000-rpm power take-off speed will

(a) Permit transmitting nearly 100 percent more power through the power take-off drive without requiring a 1¾-in. power shaft on implement and tractor.

(b) Permit a reduction in the cost of the tractor since the power take-off drive will not incorporate as

EDITOR'S NOTE: This article has been endorsed by representative members of the Technical Committee of the ASAE Power and Machinery Division.

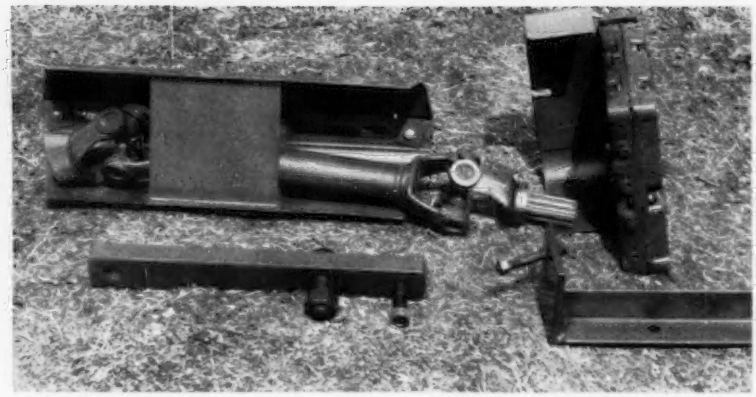


Fig.1 External power take-off conversion gearbox and related parts

. . . New PTO Standard

great a speed reduction, and for equal power the power take-off drive will be required to transmit less torque.

(c) Permit a reduction in the cost of those implements that have a principal shaft speed appreciably above 540 rpm by permitting the use of smaller and lighter universal joints and power-line drive and of smaller protective devices.

2 Involute splines provide the possibility for reduced manufacturing costs and increased torsional strength, and also prevent accidental hitching a 540-rpm power take-off implement to a tractor with a 1000-rpm power take-off drive.

3 Increasing the horizontal distance from the power shaft to the drawbar hitch point from 14 to 16 in. permits telescoping of the power line between the two forward universal joints, if so desired for any individual implement, which in turn provides for easier attachment of the tumbling shaft to the tractor as well as simplifies and improves the implement power line.

4 Reducing the vertical dimensions from the drawbar to the power take-off to 6 to 12 in. and reducing the maximum offset of the power take-off from the tractor center line to 1 in. results in better alignment of the power line especially with hitch-mounted, power-take-off-driven implements.

5 Shortening the power shaft by 1 in., increasing the horizontal distance from the end of the power take-off to the drawbar hitch point from 14 to 16 in., and reducing the minimum tire clearance from 4 to 3 in. permits the master shield to be reduced in size and moved forward, which provides considerably more space for hitch-mounted implements.

6 Provides for the possibility of greatly improved safety by improved power shaft shielding.

7 Making all of the proposed changes at one time which should avoid making non-interchangeable standard revisions for each of the proposed changes individually.

The group of engineers responsible for formulating the new 1000-rpm power take-off standard emphasizes that the foregoing advantages may not be achieved in many implements and tractors until basic new designs are introduced.

Introducing a new power take-off drive that does not interchange with the existing 540-rpm drive has a number of serious disadvantages, as follows:

1 The change to the 1000-rpm power take-off and to the 1⅜-in. involute-spline power shaft will create confusion as well as necessitate increased expense when adapting current tractors or implements to an implement or tractor built with a 1000-rpm power take-off and involute-spline power shaft.

2 The 1000-rpm power take-off speed may result in increased cost of those implements whose principal shaft speed now is essentially 540 rpm or less.

3 The cost of engineering programs on tractors and implements to bring the proposed changes into effect is substantial.

It is evident that, for the introduction of a new power take-off drive to be successful, the fact must be recognized that there are many thousands of implements and tractors now in service on farms equipped with the 540-rpm power take-off. It is also evident that the problem of operating tractors or implements equipped with 1000-rpm power take-off drives in combination with implements or tractors having 540-rpm power take-off drives, cannot be practically solved by any one method. Each tractor and each implement presents a separate problem. Further, users requiring conversion means may have many combinations of machines. In view of this situation, it appears that one of four methods will be essential in adapting a tractor with 1000-rpm power take-off drive to an implement with a 540-rpm power take-off drive, and vice versa. These methods are as follows:

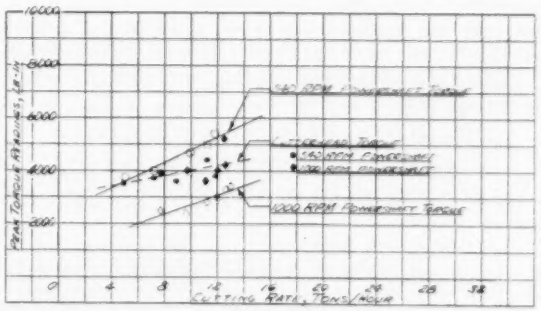


Fig. 2 Torque characteristics with medium size tractor operating a forage harvester in green alfalfa

Method 1. Encourage users and dealers to confine, wherever possible, the operation of tractors with 540-rpm power take-off drives to implements also having 540-rpm power take-off drives. Also, in selling new implement and tractor combinations, every possible effort should be made to sell tractors with 1000-rpm power take-off drives with implements so equipped. This very important essential will obviously be the main responsibility of sales organizations, and it cannot be too strongly emphasized that best tractor and implement performance will result when this essential is carried out. The fact that most farms now have more than one tractor, that many farms have only one or two power take-off driven machines, and that most sales of new tractors, as well as implements for use with them, usually include a trade-in of similar machines, should make this method quite practical in a large percentage of cases.

Method 2. When a tractor with 1000-rpm power take-off drive is sold, and it is found impractical to sell all new power take-off driven implements at the same time, the purchaser may find it desirable to convert the implements he has to the 1000-rpm speed, provided suitable conversion units are available. This method will prove particularly applicable to power take-off driven integral implements, and will be found especially practicable for those implements that can easily be changed from one operating speed to another.

Method 3. In line with Method 2, if a 1000-rpm power take-off driven implement is sold and it is not possible to sell a new tractor at the same time, the purchaser may find it to his advantage to change the internal gears and necessary drawbar parts in his tractor to the 1000-rpm standard (if such parts are available for that tractor). This method will also be found especially practicable in the case of tractors that can be easily changed from one operating speed to another.

Method 4. Where Methods 1, 2 and 3 are not applicable, the proper external conversion gearbox and necessary drawbar extension parts should be used. Where the owner has only light-duty or moderate-duty implements, a light-duty conversion gearbox will undoubtedly be the most practicable solution. However, for such implements as hammer mills, irrigation pumps, and some forage harvesters, a heavy-duty gearbox, capable of transmitting the full horsepower of the tractor, will have to be used.

(NOTE: Since there will obviously be some tractors and some implements in connection with which, for particular reasons, it will be found impractical to apply the conversions described in Methods 2, 3, and 4, Method 1 will have to be used.)

It is expected that each tractor and implement manufacturer will be prepared to make such recommendations to its customers as may be necessary for the proper conversion of tractors and implements from one power take-off operating speed to another.

The external conversion gearbox and related parts described in Method 3 are being developed by several manufacturers. This conversion unit (Fig. 1), when fitted over the spline of a 540-rpm power take-off tractor, will then provide a 1000-rpm shaft outlet.

It has always been a difficult problem to get tractor operators to so adjust the tractor drawbar as to provide the proper relationship of the drawbar hitch point to the power take-off shaft. In fact, a large percentage of power take-off drive complaints can be traced to improper adjustment of the drawbar hitch point for power take-off work. Therefore, when we begin to have implements and tractors conforming to two power take-off standards, this problem will be still further multiplied. However, in order to avoid as many of these complaints as possible, the American Society of Agricultural Engineers has changed its official recommendations, "Operating Requirements for Power Take-off Drives," to be more specific concerning the responsibility of each manufacturer in the matter of insuring that proper instructions are made available to users. This recommendation as now revised includes the following paragraphs concerning instructions to the operator:

"The tractor manufacturer shall provide instructions for safety in a prominent place on the tractor, to include the following:

"1 The normal operating speed of the rear power take-off shaft (540 or 1000 rpm).

"2 The tractor drawbar is to be adjusted and locked in a position so that the drawbar hitch point is located

"*(a)* On the longitudinal center line of the tractor power take-off shaft.

"*(b)* With the center of the implement hitch pin 14 in. to the rear of the end of the power take-off shaft for an implement and tractor combination operating at 540 rpm, and 16 in. to the rear of the end of the power take-off shaft for an implement and tractor combination operating at 1000 rpm.

"*(c)* With the vertical distance between the top of the tractor drawbar and the center line of the power take-off shaft being as close to 8 in. as possible.

(Continued on page 91)

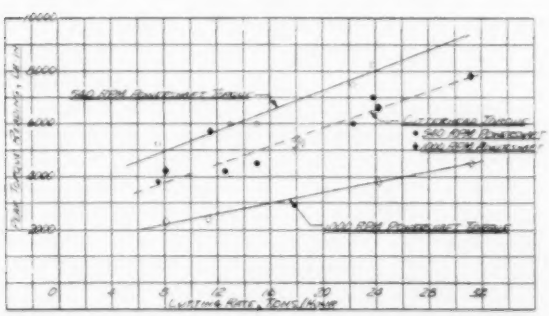


Fig. 3 Torque characteristics with large size tractor operating a forage harvester in green alfalfa

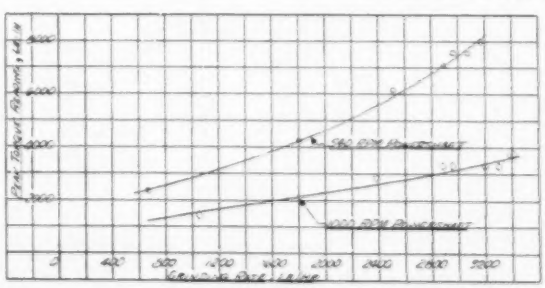


Fig. 4 Torque characteristics with large size tractor operating a hammermill

ASAE STANDARD:

1000-rpm Power Take-Off for Farm Tractors

This Standard establishes the specifications that are essential in order that any 1000-rpm power take-off driven machine may be operated with any make of tractor having a 1000-rpm power take-off drive:

1 The diameter of the hitch hole (Fig. 1) at the end of the tractor drawbar shall be not less than $^{13}/_{16}$ inch, and, in addition, an $^{11}/_{16}$-inch hole shall be provided in the drawbar 4 inches ahead of the hitch hole.

2 The material in the tractor drawbar shall clear an implement clevis (3 inches wide and having a 3-inch throat clearance) through a 90-degree swing right or left of the tractor drawbar centerline.

3 The horizontal distance (B, Fig. 1) between the hitch point on the tractor drawbar and the rearmost point on the standard-sized rubber tire, steel wheel rim lug, or tractor fender shall not be less than 3 inches.

4 The position of the tractor drawbar, for power take-off work, shall be such that the vertical distance (C, Fig. 1) from the ground line to the top of the drawbar at the hitch point shall be 15 inches $\pm$ 2 inches when the tractor is equipped with regular-sized tires.

5 The horizontal distance (A, Fig. 1) between the hitch point on the tractor drawbar and the end of the splined shaft of the power take-off shall be 16 inches. The hitch-point shall be directly in line with the centerline of the power take-off shaft, and provision shall be made on the tractor for locking the drawbar in this position.

6 The vertical distance (D, Fig. 1) between the top of the drawbar at the hitch point and the centerline of the power take-off splined shaft shall not be less than 6 inches or more than 12 inches, 8 inches being the recommended dimension.

7 The location of the tractor power take-off shaft shall be within the limits of 1 inch to the right or left of the centerline of the tractor, the tractor centerline being the recommended location.

8 The tractor drawbar shall be strong enough to carry vertical loads at the PTO drawbar hitch point in accordance with the schedule shown in Table 1, and implements designed for each class of tractor shall not impose loads in excess of these values. In Table 1, the maximum drawbar pull *(P)* is based on Test G of the Agricultural Wheel Type Tractor Test Code, the dynamic load *(W_d)* is the maximum vertical load imposed on the drawbar when operating under field conditions, and the static load *(W_s)* is the maximum vertical load imposed on the drawbar with the implement and tractor combination at rest on level ground.

TABLE 1. TRACTOR DRAWBAR VERTICAL LOAD LIMITATIONS

Tractor class	P Maximum drawbar pull, lb	W_d Maximum vertical dynamic load, lb	W_s Maximum vertical static load, lb
A	0-2000	1250	500
B	2000-3500	1875	750
C	3500-6000	2500	1000
D	6000 and up	3750	1500

9 The tractor power take-off shaft (except belt pulley shafts) for power take-off drives extending from the tractor to the rear shall have the dimensions shown in Fig. 2. A minimum clearance spherical radius of $3^1/_4$ inches as illustrated in Fig. 2 shall be provided. The spline shaft groove shown in Fig. 2 is provided for a retaining means where required. The option of the major diameter fit is recommended for applications encountering greater radial load than can successfully be transmitted with the option of a tooth side fit; also, hubs incorporating a clamping means along with the option of the tooth side fit are recommended for applications encountering loads of sufficient magnitude so that hubs without clamping means are found inadequate.

10 The normal speed of the rear power take-off shaft, when operating under normal load, shall be 1000 rpm $\pm$ 25 rpm. The direction of the rotation shall be clockwise when facing in the direction of forward travel. It is recommended that an instrument indicating the normal speed of the power take-off shaft, when operating under normal load, be made

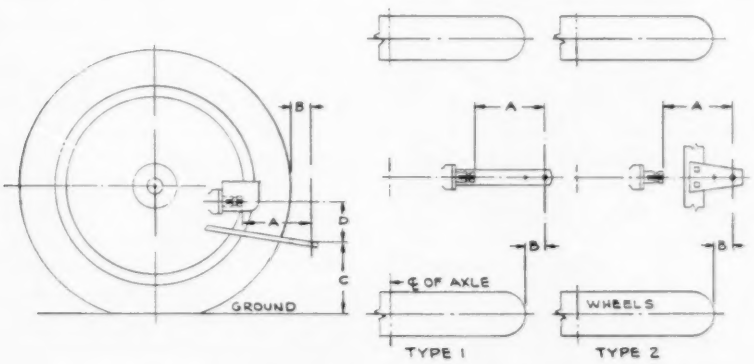


Fig. 1 Drawbar hitch and power take-off locations for farm tractors

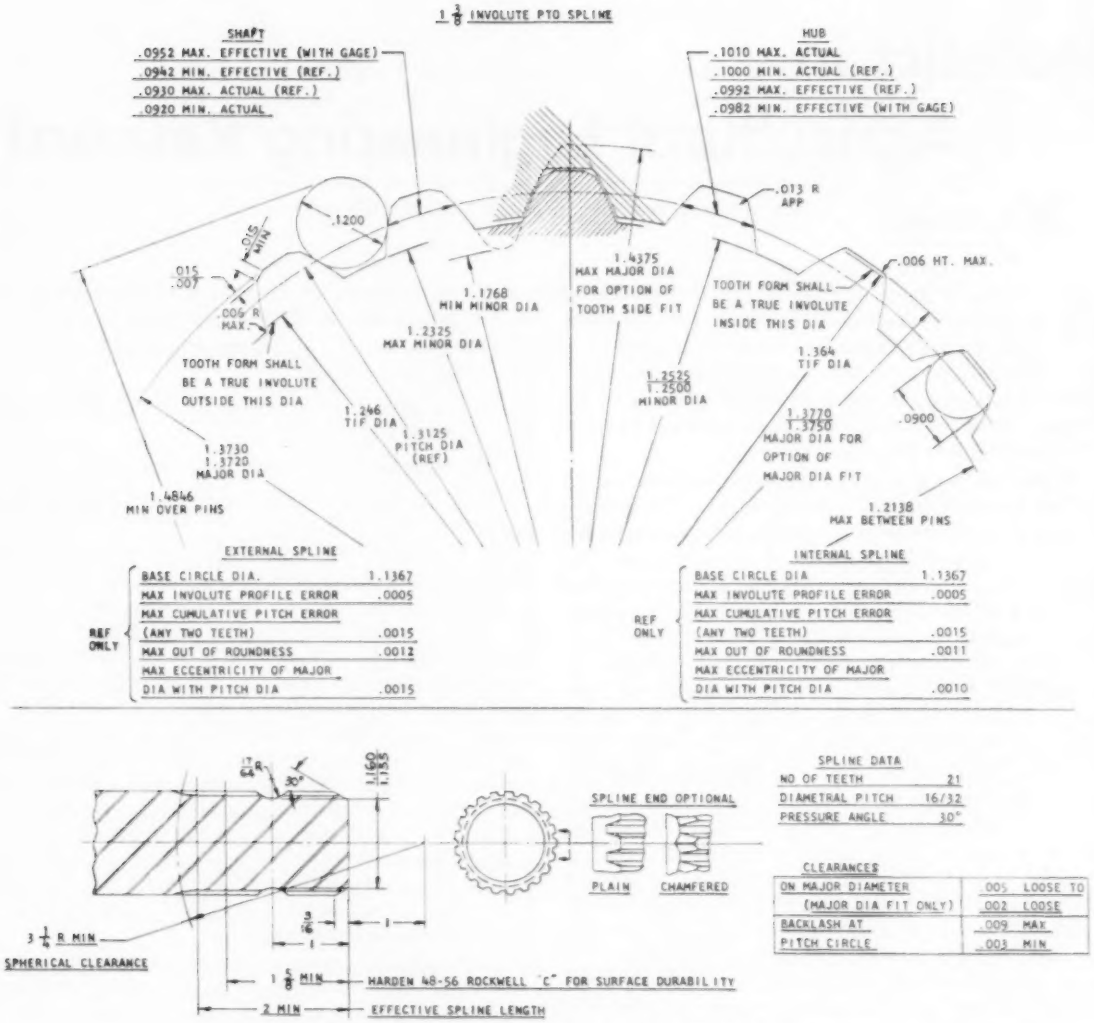

1 3/8 INVOLUTE PTO SPLINE
SHAFT
.0952 MAX. EFFECTIVE (WITH GAGE)
.0942 MIN. EFFECTIVE (REF.)
.0930 MAX. ACTUAL (REF.)
.0920 MIN. ACTUAL
HUB
.1010 MAX. ACTUAL
.1000 MIN. ACTUAL (REF.)
.0992 MAX. EFFECTIVE (REF.)
.0982 MIN. EFFECTIVE (WITH GAGE)
.013 R APP
.1200
.015 MIN
.015 .007
.006 R MAX.
1.4375 MAX MAJOR DIA FOR OPTION OF TOOTH SIDE FIT
1.1768 MIN MINOR DIA
1.2325 MAX MINOR DIA
TOOTH FORM SHALL BE A TRUE INVOLUTE OUTSIDE THIS DIA
TOOTH FORM SHALL BE A TRUE INVOLUTE INSIDE THIS DIA
.006 HT. MAX.
1.364 TIF DIA
1.2525 1.2500 MINOR DIA
1.246 TIF DIA
1.3125 PITCH DIA (REF)
1.3730 1.3720 MAJOR DIA
1.4846 MIN OVER PINS
1.3770 1.3750 MAJOR DIA FOR OPTION OF MAJOR DIA FIT
.0900
1.2138 MAX BETWEEN PINS
EXTERNAL SPLINE
REF ONLY
BASE CIRCLE DIA. 1.1367
MAX INVOLUTE PROFILE ERROR .0005
MAX CUMULATIVE PITCH ERROR (ANY TWO TEETH) .0015
MAX OUT OF ROUNDNESS .0012
MAX ECCENTRICITY OF MAJOR DIA WITH PITCH DIA .0015
INTERNAL SPLINE
REF ONLY
BASE CIRCLE DIA 1.1367
MAX INVOLUTE PROFILE ERROR .0005
MAX CUMULATIVE PITCH ERROR (ANY TWO TEETH) .0015
MAX OUT OF ROUNDNESS .0011
MAX ECCENTRICITY OF MAJOR DIA WITH PITCH DIA .0010
1/64 R
30°
CHAMFER 1/32 X 45°
SPLINE END OPTIONAL
PLAIN
CHAMFERED
SPLINE DATA
NO OF TEETH 21
DIAMETRAL PITCH 16/32
PRESSURE ANGLE 30°
CLEARANCES
ON MAJOR DIAMETER (MAJOR DIA FIT ONLY) .005 LOOSE TO .002 LOOSE
BACKLASH AT PITCH CIRCLE .009 MAX .003 MIN
3 1/16 R MIN
SPHERICAL CLEARANCE
3/16
1
1
1 5/8 MIN
HARDEN 48-56 ROCKWELL "C" FOR SURFACE DURABILITY
2 MIN
EFFECTIVE SPLINE LENGTH

Fig. 2 1⅜-inch-diameter rear power take-off spline dimensions

available for farm tractors. Such an instrument shall be provided as a part of any farm tractor capable of driving the rear power take-off shaft in excess of 1100 rpm when operating under load.

11 The tractor shall be equipped with a power take-off master shield (Fig. 3), incorporating the attaching point for the shield of the driven machine as dimensioned.

12 The strength of the master shield shall be sufficient to support the weight of the operator without taking a permanent set.

13 Both towed and integral-type power take-off driven machines shall be equipped with adequate shielding for that portion of the power line that is furnished as a part of the driven machines. This shielding shall prevent the operator from coming in contact with rotating members of the power line between the implement and tractor. Where integral power take-off driven implements are of a design requiring removal of the tractor master shield, such implements shall also include adequate protection for that portion of the tractor power shaft which protrudes from the tractor.

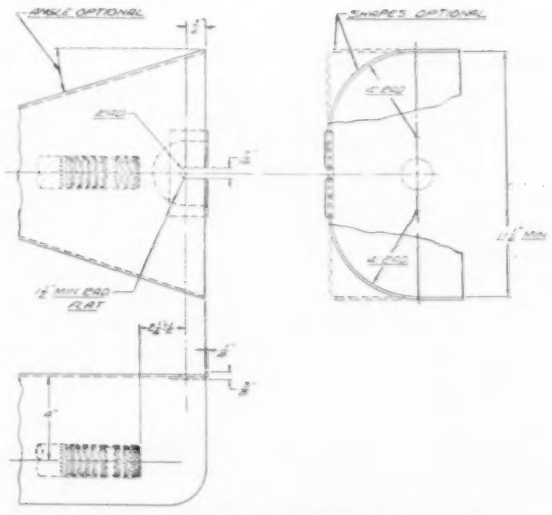


Fig 3 Power take-off master shield for the tractor

Statistics in Agricultural Engineering Research

E. L. LeClerg

AN IDEAL situation would be for every experimenter to know his science and the science of statistics. The mastery of two sciences, however, is not possible for most research men. Some statisticians feel that the lack of mathematical training is the most serious handicap of the scientist. In all probability equal concern should be given to his concepts of the scientific method.

In general, an experiment is conducted to answer certain questions posed in advance by the investigator. The question or questions to be answered constitute one of the important factors in determining the design of an experiment. The design of the experiment represents, in part, the procedure by which data will be obtained to form the basis for answering the question or questions sought from the experiment. Subsequent analysis of the data is a means of determining the reliability of the data from which conclusions are to be drawn. It should be recognized that the procedure for the analysis of the data is an integral part of designing an experiment. This emphasizes the need for the investigator to foresee his requirements with sufficient certainty and to choose the type of experimental design which will satisfy them.

Many experiments are started without a well thought out set of objectives in the hope that the data collected will furnish both the questions and the answers. A researcher once said, "It is likely that some of these debatable points can be adjusted after the tests gets under way and that the test will provide certain valuable information." Unfortunately, this situation is all too common among research men.

Improper consideration to experimental design may lead to obscure or misleading results.

Experimental Design

An example provided by Professor Snedcor of Iowa State College illustrates the importance of proper experimental design. Six protein supplements were fed to chicks to estimate their relative effects on gain in weight. All the chicks receiving Treatment A were kept in Pen I, and similarly the chicks receiving each of the other five protein supplements were kept in separate pens. The sexes were mixed in unknown ratios and the supplements were used in equal weights irrespective of protein content. No record was kept of individual food consumption. Based on the statistical analysis, if the lot having Treatment A, gained significantly more than the lot having Treatment B, the answer might be,

(a) the concentration of protein in Treatment A was greater than that in Treatment B or

(b) there was a larger proportion of males in Lot A than in Lot B, or

(c) the environmental conditions were more favorable in Pen I, or

(d) supplement A was more appetizing than B.

Thus, the difference to be tested could not be identified and therefore was meaningless.

As an example of another improperly designed experiment, suppose we compare three types of bin for the storage of wheat. For the test, one of each of the three types of bin was constructed and placed so that no one of them would be specially protected by the others or favored by other environmental conditions. The three bins were then filled on the same day under as nearly as possible identical conditions with wheat that was as uniform in regard to all characteristics that might affect storage. Using the most precise instruments obtainable, temperature, humidity, and other pertinent information was secured at definite time intervals and the storage damage was measured by determining the rancidity of the oil in the wheat. In spite of all this care, the results of this test have limited scientific value because lack of replication could cause results to be unreliable and frequently misleading.

In all adequate designs, regardless of name, the purpose is two-fold, namely to determine the difference of effect and to provide a valid estimate of the variability of the effects of treatments in the same bin, the so-called experimental error. For all these designs, there are two requisites — replication and randomization.

Replication and Randomization

Replication serves two functions, namely to diminish the error of treatment means and provide an estimate of experimental error. The first function relates to the precision of an experiment which serves as a measure of the sensitivity of an experiment when a test of significance is to be used. Of course, there are additional ways of increasing the precision of an experiment, such as using better materials, instruments, and workers. The need for an estimate of experimental error is apparent from the doubts raised in interpreting the results of an experiment involving only a single observation for each treatment. In such a situation no basis is available to determine whether treatment differences are real or only due to uncontrolled sources of variability. Replication, however, is only one condition necessary to obtain a valid estimate of experimental error — the other is randomization.

The sole purpose of randomization is to insure that the estimate of error is valid. This is accomplished by assuring

Condensation of a paper presented at the meeting of the Washington, D.C. Section of the American Society of Agricultural Engineers in Washington, D.C., May 1956.

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There was a time, states the author, when statistics as a tool in experimentation were almost completely ignored by the experimenter; in fact, it was regarded as "introducing unnecessary confusion into otherwise plain issues." This position, although still persisting in some quarters has given way to the application of mathematical models to experimental data. This article presents simple types of problems in which a statistical analysis can be helpful.

that every individual in the population under consideration shall have the same probability of being chosen in the sample. Such a criterion implies that all treatments or treatment combinations be independent. The best way of insuring independence in a sample is to utilize some device for selecting the treatments — random numbers, drawing from a hat, etc. It turns out that, in general, the only good method of sampling is a random method. In a random method the sample is picked so that personal choice or prejudice are being completely excluded. Thus, randomization is an insurance against bias in the results for particular factors and at the same time makes valid the computation of the experimental error.

It is not the purpose of this discussion to present any new designs or any new relations between the design of an experiment and the analysis of the results. Instead, the discussion will be limited to the usefulness of the factorial experiment and the importance of interactions in interpreting experimental results.

Factorial Experiments

Most experimenters appreciate the danger of making recommendations based on results of experiments in which only one factor or variable was varied at a time and all others were held constant. The factorial experiment permits the simultaneous study of two or more factors each at two or more levels in all combinations in the same experiment. This permits a wider inductive basis upon which to draw inferences and make recommendations.

A factorial experiment enables the experimenter to make efficient use of his facilities. The following example illustrates how such an experiment on weed control in cotton evaluates the effects of flame intensity and timeliness of application on injury of cotton plants at different stages of development (age). These variables could be:

(a) Flame intensity:
Low — 3 mph at 30 lb pressure
High — 4 mph at 60 lb pressure

(b) Timeliness of application (weed stands artificially established):
Early — grass and weeds 1 to 3 in. tall
Late — grass and weeds 5 to 6 in. tall

(c) Age of cotton plants:
4 in. tall
6 in. tall
8 in. tall

These three variables may be combined into what is known as a 2X2X3 factorial requiring 12 plots for a single replication; for two replications 24 plots being required.

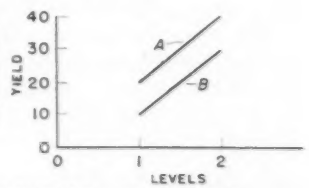
A schematic arrangement of the three variables (flame intensity, timeliness of application, and age of cotton) may be summarized as:

- Low flame intensity
  - Early application
    - 4 in. tall
    - 6 in. tall
    - 8 in. tall
  - Late application
    - 4 in. tall
    - 6 in. tall
    - 8 in. tall
- High flame intensity
  - Early application
    - 4 in. tall
    - 6 in. tall
    - 8 in. tall
  - Late application
    - 4 in. tall
    - 6 in. tall
    - 8 in. tall

In such an experiment every one of the 24 plots of the two replications is used to evaluate the effect of: *(a)* flame intensity; *(b)* timeliness of application, and *(c)* age of cotton plants. Such multiple use of plots becomes evident when the way is considered in which the treatment variables are combined. It is apparent from the above list of treatments that the 12 plots in each replication are each treated differently. For example, six receive low flame intensity and six high flame intensity. But in each set of six, flaming is applied early to three plots and late to another set of three

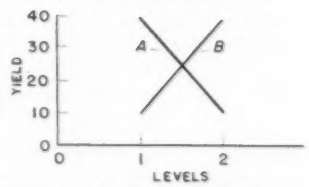
(a) NO INTERACTIONS

VARIABLE	LEVELS 1	2	TOTAL
A	20	40	60
B	10	30	40
TOTAL	30	70	100



(b) COMPLETE REVERSAL INTERACTION

VARIABLE	LEVELS 1	2	TOTAL
A	40	10	50
B	10	40	50
TOTAL	50	50	100



(c) CHANGE IN MAGNITUDE INTERACTION

VARIABLE	LEVELS 1	2	TOTAL
A	15	50	65
B	10	25	35
TOTAL	25	75	100

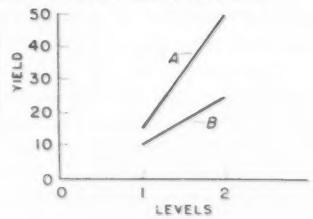


Fig. 1 Examples and schematic representation of interactions among two experimental variables

plots. These four sets of three plots each are symmetrical with respect to the age of the cotton plants, one plot in each set comprising cotton 4 in. tall, one with 6-in. plants, and the third with 8-in. plants.

Thus, this type of experiment with two replications provide:

12 plots on which flame intensity was low, and
12 plots on which flame intensity was high.

Any difference in injury of cotton between these two sets may be assigned to the particular respect in which they differ providing the variables are independent in their effect and with allowance for random or sampling fluctuation.

The same condition exists with respect to the timeliness of application of the burning, i.e.,

12 plots of the 24 receive early application, and
12 plots of the 24 receive late application.

The difference between these two sets may be assigned to the timeliness of application with proper allowance for sampling error and providing all variables are independent in effect.

Finally, the three groups of eight plots of each age group (4, 6, and 8-in. cotton) provide an estimate of the relation of development (age) of cotton plants to flame injury because they are symmetrical with regard to the other two variables, flame intensity and timeliness of application.

For each of these three main comparisons the same precision is obtained as though the entire 24 plots had been used to test only one of the three variables, providing the three variables are independent in their effect. If these variables had been tested separately, a total of 72 plots would have been required to obtain the same information available from the 24 plots when combined as they have been to form a factorial experiment of two replications.

This is not the only advantage of the factorial experiment. A further and important advantage would be the additional information that is available for the evaluation of the interaction of intensity and timeliness, intensity and age, timeliness and age, and of intensity and timeliness and age.

Interactions

An interaction may be defined as the failure of one variable to react the same throughout regions or levels of another variable. It might be more appropriate to speak of an interaction as differential response. Its exact significance will be most easily comprehended by the following examples.

In Fig. 1a it shows that where no interaction exists the lines for A and B of one variable at the two levels of the second variable are parallel. In this case generalizations can be made as to the overall superiority of A over B and of level 2 over level 1. Such is not the case when significant interactions are present in data.

The types of interactions are generally recognized; these are *(a)* complete reversal as illustrated in Fig. 1b and *(b)* interaction of magnitude as illustrated in Fig. 1c. In both of these cases, interpretation must be made specifically for each variable at each level since the first variable does not respond the same at the two levels of the second variable.

The illustration of weed control will serve as an example of the method of determining interactions. If late application of flaming causes only little injury to cotton when low flame intensity is used, but considerable injury when high flame intensity is used, this fact is discernible only by testing the late application of flame under conditions of low and high flame intensity of the 24 plots. In this situation,

6 plots receive late application of high flame intensity
6 plots receive early application of low flame intensity.

These 12 plots provide a group to compare with another group of 12 of which,

6 plots receive late application of low flame intensity
6 plots receive early application of high flame intensity.

This, then provides a comparison of two sets of 12 plots comparable in all respects except the one in question, that is, whether the effect of late application on injury is influenced by the intensity of flame. If no interaction exists, the expected difference within random error between these two sets of plots would be zero, but if the response to flame intensity is not the same for both early and late application, the difference between these two sets would reflect the interaction. This interaction is known as the interaction between flame intensity and application.

Thus, in this factorial experiment, not only are the main effects of the three variables measured with all the plots in the entire experiment but also all possible interactions between them have been measured with all the plots. To attempt to answer all of the questions by letting but one variable vary at a time would require a large number of experiments with consequent loss of the opportunity to measure the effect of interactions.

Types of Other Factorials

It should be emphasized that factorial experiments are not limited to just two or three variables as previously described. They may be used with any number of variables. It will be readily recognized, however, that experiments involving a large number of variables may impose physical limitations. This is illustrated by the number of treatment combinations involved for the factorial experiments listed in the following table.

Type of Experiment — Number of Variables	Number of Treatment Combinations
2^3 (2X2X2)	8
2^4 (2X2X2X2)	16
3^3 (3X3X3)	27
3^4 (3X3X3X3)	81
4^3 (4X4X4)	64
4^4 (4X4X4X4)	256
5^3 (5X5X5)	125
5^4 (5X5X5X5)	625

To make for more efficient research, the wider use of factorial experiments is recommended.

The examples that have been discussed are of the more simple types of problems in which a statistical analysis helps the experimenter. The procedures can be generalized so as to deal with more complicated experiments. However, the point to be emphasized is not that the engineer be able to apply the various statistical methods himself, but that he should appreciate the main features of a statistical argument and should recognize when proper experimental design and statistical analysis are essential to appropriate interpretation of his data. Close cooperation between the engineer and the statistician is necessary if the maximum information is

to be obtained from experimental data. In this regard, the statement made by Trullinger (1)*, is significant. He said, in part, ". . . the most effective participation in agricultural research by engineers is that which begins at the planning stage and continues in cooperation with the other essential scientific approaches throughout the life of a research project, in the form of either advice or action, or both."

Statistics is one of the "other essential scientific approaches" and for effective research the statistician should be an integral part of the research team. Finally, a few words of warning. Yates (2) appropriately emphasized, "Don't expect too much of statistics, or the statistician. Don't for instance, expect every bit of statistical analysis to yield useful results, and don't be afraid of consigning the unprofitable bits to the waste basket, or at least to the filing cabinet. Don't when you have collected a mass of numerical data which do not appear to be making any very clear statement, expect that the statistician will necessarily be able to reveal the hidden truths that have escaped you. He may be able to help you, but equally the data may just not be capable of revealing anything. Don't clutter up your scientific papers with details of arithmetic which are better left in a notebook. And above all, obtain statistical advice at the planning stage, as well as after the results have been collected."

References

1 Trullinger, R. W. Why and how agricultural research involves agricultural engineers. AGRICULTURAL ENGINEERING 21: 381-384, 397. 1940.

2 Yates, F. The place of statistics in agricultural research. Agr. Prog. 21: 1-10. 1946.

*Numbers in parentheses refer to the appended references.

. . . New PTO Standard

(Continued from page 85)

"3. The power-line safety shields are to be kept in place.

"The implement manufacturer shall provide for safety instructions in a prominent place on the implement, to include the following:

"1 The normal operating speed of the power take-off drive to the implement (540 or 1000 rpm).

"2 The power-line safety shields are to be kept in place.

"Operators' manuals for both tractors and power take-off driven implements shall include the foregoing information.

"If a conversion assembly is made available for changing tractors or implements from the 540-rpm to the 1000-rpm power take-off standard, or vice versa, these conversion assemblies shall include an instruction plate or sticker specifying the power take-off speed and the corresponding drawbar adjustments."

The results of some experimental tests which show the advantages of the new power take-off standard are of interest to all concerned. A series of tests was conducted in which a medium-sized tractor was used to operate a forage harvester chopping green alfalfa. Electronic torque meters were placed in the power line between the implement and the tractor, and also adjacent to the chopper cutterhead. The tractor and implement were first operated as combinations conforming to the current 540-rpm power take-off standard and torque measurements were recorded at various cutting rates. Next the same tractor and implement were converted to the 1000-rpm power take-off standard and the same tests were repeated. The medium-sized tractor was then replaced with a large-sized tractor and the comparison was again made at both power take-off speeds. Then, a similar comparison was made with the large-sized tractor operating a hammer mill (no cutterhead data). The results of these tests are shown graphically in Figs. 2, 3 and 4. The results of these tests revealed quite conclusively that

1 The torque transmitted by the tumbling shaft, which is usually the most vulnerable member of the power line, is reduced in direct proportion to the increase in operating speed.

2 The performance of the implement at the cutterhead or the hammer-mill head was not affected by the speed of the tumbling shaft.

The introduction of the continuous-running type of power take-off has greatly increased the utility of this type of drive. Many implements formerly available with engine drive only are being converted to the less costly power take-off drive. This extended usage has imposed greater design requirements on the entire power line including both implement and tractor.

Use of the 1000-rpm power take-off standard will affect interchangeability between implements and tractors as previously mentioned. The changes will, however, permit engineers to develop a better design of power-line connection between implement and tractor, including connection to the power take-off shaft more easily and more effective power-line shielding.

These needed improvements, together with the ability to transmit more power through the power line, will permit still greater utilization of this type of drive with provision for new implements of greater capacity and tractors with increased power and higher engine speeds.

The question of primary concern to many readers will now naturally be as to when production machines, which conform to the 1000-rpm power take-off standard will be available to purchasers. Since this standard was developed through cooperative engineering effort by the leading tractor and implement manufacturers, it can naturally be assumed that at least some of these manufacturers will be interested in offering products to the farm market which conform to the new standard. If this were not the case, it is doubtful that a sufficient number of manufacturers would have supported the effort that has resulted in their approval of the standard. Obviously problems of individual manufacturers are vastly different and it can therefore be assumed that they will introduce machines conforming to the new standard only at such times that they find it to their individual advantage to do so. It is known, however, that a large majority of manufacturers in the industry have active engineering programs aimed at evaluating the new standard when applied to their particular implements and tractors. Many of these manufacturers no doubt now have definite production plans which they will announce when their machines are ready for the market.

Low Cost Subsurface Drainage

Charles D. Busch
Assoc. Member ASAE

THERE is a nationally recognized need for reducing the cost of subsurface drainage to facilitate efficient and effective farming operations. The present high cost of labor, equipment and materials results in excessively high investment costs for farmers who are installing this type of drainage. The U.S. Soil Conservation Service estimates that nearly 19,000 miles of closed drains were installed during the calendar year of 1956. Over 1,000 miles were in the 13 northeastern states. The national annual cost is estimated at nearly 15 million dollars. Obviously any saving through development of a low cost subsurface drainage technique could easily result in an annual national savings of several million dollars.

The present subsurface drainage methods, when considered from a materials-handling aspect, offer considerable latitude for such improvement. In the customary installation, the trencher first removes about 4½ cu ft of earth to create one foot of ditch wide enough for a man to work in and of 3-ft depth for the tile. At a rough estimate of 95 lb per cu ft, this represents over 400 lb of soil. Next, the conduit (tile, fiber pipe, etc.) — which is handled numerous times in transit from the factory to the supplier to the farmer to the ditch — must be lifted into the trench, aligned, and partially backfilled by hand to insure a satisfactory installation. Finally, the refilling of the ditch again requires the movement of over 400 lb of material per foot of drainage tile. The time and energy required for such an installation limits the average daily output to about 1,000 ft with a team of three or four men.

Lowering the cost of conventional subsurface drainage practices could readily be accomplished by a reduction in the amount of material which is handled in both the ditch digging and hand labor. This concept is by no means unique. It has formed the basis on which all past and present work is predicated. To date, however, no method has met with sufficient success to find widespread, practical application.

Past and Present Research

Probably mole drainage constitutes the earliest, and undoubtedly, the lowest initial cost subsurface drain. In mole drainage, a channel is forced through the soil by the mole plow at a depth of 2 to 3 ft with an accompanying blade slit to the surface. The advantage of this type of operation is the simplicity of installation — one machine, operated by only one man in one pass across the field establishes the channel. It can be accomplished at a small fraction of the cost of tiling. Unfortunately, in other than certain clay or organic soils, the depth, stability, and grade of such an installation leaves much to be desired.

Experimental machine positions slitted plastic strip to form an arch lining for mole-type drains

Attempts to improve on the mechanized formation of a channel and its stabilization by adding or inserting material date back to the early 1930's. The Poppelsdorf method (1)* succeeded in pulling a string of tiles into the ground. H. Sack (2) formed galvanized sheet metal into a tube and pulled it into the ground. More recently, in Germany, Janert (3) has experimented with bituminous tar materials to strengthen the mole channel, and, in Iowa, G. O. Schwab (4) has demonstrated the possibilities of using perforated polyethylene tubing pulled into the mole channel. Unfortunately these methods and others of a similar nature met with only limited success and have not been widely adopted.

The search currently continues, however, since the rewards of perfecting a low-cost subsurface drain still appear to be great. A. N. Ede (6) of the University of Cambridge reported initial success utilizing a machine that passes freshly mixed concrete down a 4-in. outside-diameter tube to form a porous lining in a mole channel. This machine will operate at normal speeds of 8 fpm, and at a depth of 30 in. in any soil except rock. It also has means for filling with gravel the one-inch slit left by the mole blade. Drains laid by this machine have withstood one season without evidence of deterioration. The costs are reported as about 25 percent that of machine-laid conventional tile drains. Mr. Ede is also developing a second machine mounted on a heavy track-type tractor and utilizing a liquid concrete mixture. It is reasonable to believe that these methods face difficulties in simultaneously obtaining both stability and porosity in a concrete lining, a point which has been limiting in similar previous studies.

H. Janert (5) at the University of Griefswald has developed and reported a mechanized drainage machine which can lay a 1.4-in.-diam pipe down to 2½ ft at 0.2 mph. The pipe is made from a plastic or bituminized cardboard sheet which is heated and formed by means of rollers. Here again, the author indicates a cost of one-quarter that of conventional tile drainage. The size of the drain tube, however, makes it unsuited for the present recommendations in this country. Furthermore, to increase the diameter to 3 in. would necessitate a trench almost a foot wide if the equipment was to follow the same general design used for the 1.4-in. drain.

Investigations at Cornell

The investigations at Cornell University have to date been independent of the other work currently going on. Initially the lowest cost subsurface drain — the plain mole drain — was examined to determine the cause of failure in a

*Numbers in parentheses refer to appended references.

Paper presented at the North Atlantic Section meeting of ASAE at the University of Delaware in Newark, Dela., August 1957.

The author — CHARLES D. BUSCH — is an agricultural engineer, Eastern Section (SWCRD, ARS) USDA, Ithaca, N. Y. The project is in cooperation with the agricultural engineering department, Cornell University.

Acknouledgment: The author expresses his appreciation for the continuing interest and cooperation of the Bakelite Co. and the Caterpillar Tractor Co. and for the plastic materials, machinery and helpful suggestions they have contributed to make this project possible.

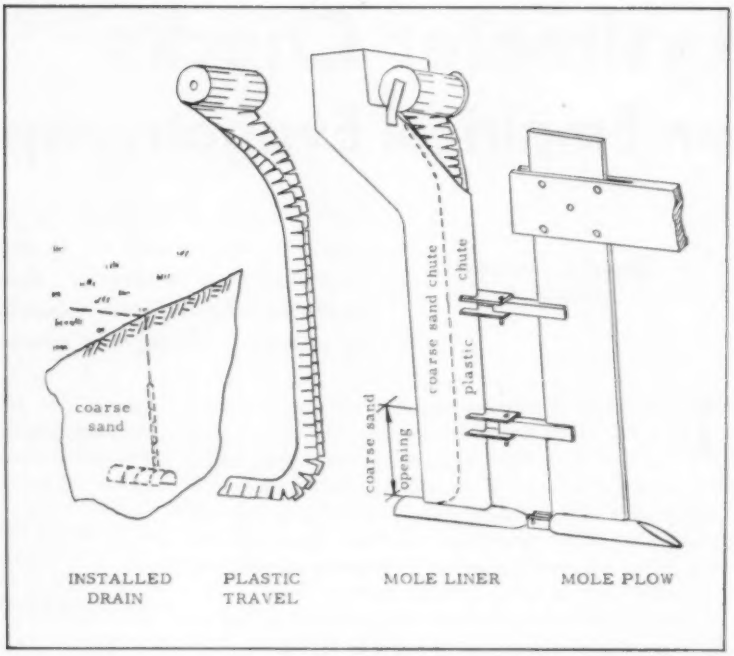


Fig. 1 Mole liner attached to mole plow positions slitted plastic strip to form an arch for mole drain. Coarse sand is used to maintain a porous passage from plow depth to drain

lacustrine silty clay loam soil where success seemed probable. The first site investigated was one of three-month-old mole channels. Here the mole channel and slit were found to be in excellent condition. There was little visible evidence of caving and the smooth surfaces made by the machine could still be seen. However, on the floor of the 3-in-diam channel over an inch of soil had been deposited, which observation, and chemical and mechanical analysis showed to be topsoil. It had undoubtedly fallen through the open slit and represented partial blockage of the channel. A beginning of root growth into the slit and channel was also observed, plus several live rodents and numerous insects inhabiting the channel.

For a preliminary trial of loading effects, these mole drains were subjected to a pressure of over 25 psi applied by running one track of a heavy track-laying machine onto a one-foot-square block centered over the channel. Its effect was to instantaneously slam the slit closed without noticeably affecting the channel's shape. Since a mole drain is dependent to a large extent on flow through the slit, any similar closing effected by an agricultural implement would lower the drain's efficiency.

(Continued on page 97)

Fig. 2 The lining machine was adapted to fit behind an experimental mole plow designed by the Caterpillar Tractor Co.

Lysimeter Checks on Empirical Evapotranspiration Values

Lloyd L. Harrold
Member ASAE

Advancements in methods for estimating evapotranspiration values show promise as aids for improving efficiency in water usage and increasing crop production. Results of recently developed methods compared with lysimeter measurements have been encouraging from the standpoint of apparent accuracy and adjustments for improvement

THE field of agriculture has, in recent years, witnessed notable advancements in the knowledge of water use by crops. Irrigation "by guess" is being recognized as either wasteful of our water resources or falling short of its most efficient use. Among the many important factors necessary to the proper design and operation of irrigation systems is the crop consumptive use, or evapotranspiration rate for various crops in many different localities.

These values are also useful in estimating antecedent soil moisture prior to storms — a key factor in evaluating watershed infiltration rates and excess water volumes for various periods.

One of the most recent reports on methods of estimating soil moisture conditions and time for irrigation with the evapotranspiration method was compiled by C. H. M. van Bavel (1)*. He presents in simplified form tables of daily evapotranspiration amounts for three different weather conditions — normal, dull-cloudy, and bright-hot — and for localities between 34 to 40 and 34 to 30 deg latitude. Growing-season values for a locality such as Coshocton, Ohio, about 40 deg N latitude, are shown in Table 1.

Paper presented at the Winter Meeting of ASAE in Chicago, Ill., December 1956.

The author — LLOYD L. HARROLD — is project supervisor, (SWCRD, ARS), USDA, and is in charge of the soil and water experiment station located at Coshocton, Ohio, and operated in cooperation with the Ohio Agricultural Experiment Station.

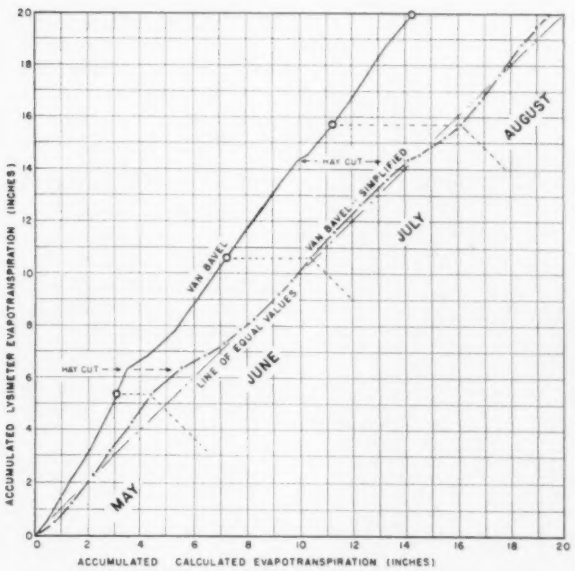


Fig. 1 Comparison of evapotranspiration values derived by van Bavel methods with measured values on meadow lysimeter Y102C by double mass curves, May-August 1956

TABLE 1. VAN BAVEL SIMPLIFIED VALUES OF EVAPOTRANSPIRATION FOR LATITUDE OF 40 DEG

Month	Daily evapotranspiration for climate of Dull-cloudy	Normal	Bright-hot
April or September	0.08 in.	0.11 in.	0.14 in.
May or August	.11	.14	.19
June or July	.14	.17	.23

Van Bavel also used extraterrestrial radiation (R_A), sunshine, and air temperature to derive daily evapotranspiration values. These are also compared with measured values at Coshocton. At this point it is well to emphasize that these procedures were intended to evaluate daily evapotranspiration over large areas. The Coshocton lysimeter data which are considered precise are used to appraise the van Bavel values and to suggest refinement factors where it is desired to estimate more exact values for irrigation or other purposes.

Thornthwaite (2) and Blaney-Criddle (3) also developed methods to evaluate evapotranspiration. Monthly evapotranspiration values were derived by these four methods for comparison with lysimeter data of the Coshocton station.

Measurements

Measurements of daily evapotranspiration were made on irrigated weighing lysimeter Y102C at the Coshocton station. These values are believed to be the most accurate obtainable by measurements which approximate field conditions and were assumed to be reliable. They represent the daily loss in moisture — evapotranspiration minus condensation (ET-CA). They were, therefore, used as a basis of comparison with evapotranspiration values derived by empirical formulæ.

The Coshocton weighing lysimeters as described by Harrold and Dreibelbis (4) were designed and constructed so as to minimize border effect and the cutting off of the soil profile and to provide a natural soil profile. The surface area is 1/500 acre in area. The entire soil profile and three feet of shale rock is included in the 8-ft lysimeter depth. Percolation water drains into the cracks of the shale

*Numbers in parentheses refer to the appended references.

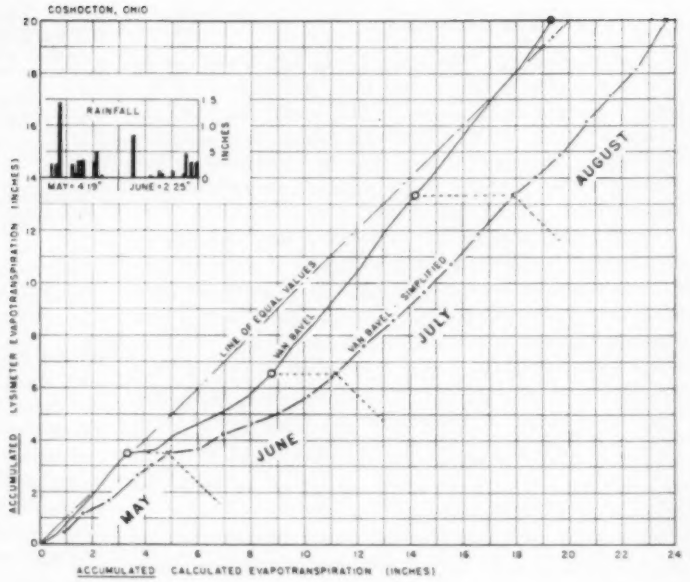


Fig. 2 Comparison of evapotranspiration values derived by van Bavel methods with measured values on irrigated corn lysimeter Y102C by double mass-curves, May-August 1953

rock in the lysimeter as it does in the field, since the contact between soil and rock has not been disturbed. Gravity water from the shale in the lysimeter is collected and measured in tanks. Capillary rise of water through cracks in the shale rock would be extremely small — if any at all — either in the field or in the lysimeters.

TABLE 2. ESTIMATED AND MEASURED DAILY EVAPOTRANSPIRATION (May, 1956)

Date	Climate judged	Temperature deg F	Sunshine percent	van Bavel calculations Evapotranspiration Detail (R_A=0.620) in.	van Bavel calculations Evapotranspiration Simplified in.	Lysimeter measurements in.
1	M	50	87	0.13	0.14	0.16
2	L	54	0	0	.11	0
3	H	57	68	.12	.19	.14
4	L	48	40	.07	.11	.05
5	H	50	71	.10	.19	.16
6	H	65	60	.12	.19	.15
7	L	50	52	.08	.11	.16
8	M	46	100	.13	.14	.19
9	L	56	33	.05	.11	.17
10	L	62	0	.01	.11	.03
11	H	70	87	.13	.19	.29
12	H	72	80	.17	.19	.20
13	H	74	91	.19	.19	.27
14	M	67	43	.09	.14	.27
15	L	54	0	.01	.11	.04
16	M	44	90	.12	.14	.17
17	L	48	43	.06	.11	.06
18	M	50	93	.13	.14	.16
19	M	55	93	.15	.14	.28
20	M	53	96	.15	.14	.24
21	H	63	80	.15	.19	.30
22	L	68	47	.10	.11	.12
23	L	62	42	.09	.11	.20
24	H	46	100	.13	.19	.23
25	H	52	100	.15	.19	.26
26	M	61	37	.07	.14	.24
27	L	61	5	.02	.11	.01
28	L	62	20	.04	.11	.23
29	L	69	37	.08	.11	.18
30	L	71	49	.11	.11	.21
31	M	68	38	.08	.14	.21
Total	—	—		3.03	4.40	5.38

During the irrigation season there is little or no percolation. Daily weight changes of the lysimeter unit are therefore mostly evapotranspiration. The scales are accurate to 5 lb which is about 0.01 in. of water. The method used to obtain evapotranspiration data from the weight records, and the limitations of data obtained from these lysimeters, have been described by Harrold and Dreibelbis (5).

Discussion

Data for 1956, a second-year meadow (alfalfa-timothy) and for 1953, corn, were chosen for this comparative study. Moisture supply in both years was never a limiting factor in the production of crops. Results are believed to be comparable to those under normal field irrigation conditions. The months May, June, July, and August cover the period in this region when irrigation might be used.

Data in Table 2 show for May, 1956, daily evapotranspiration values as measured by the Coshocton lysimeter and as derived from van Bavel's curves and from his simplified method. Daily climatic factors of sunshine, air temperature, and observer's judgment factors of L=dull-cloudy; M=normal, and H=bright-hot used in the calculations are also given. A casual inspection of these data show a wide difference between the three values for each day. There is also a noticeable lack of consistency in these differences. Values of the day-by-day extraction of soil moisture are not, however, as vital to the design and operation of irrigation systems as the removal of water for groups of several days. In order to compare the different evapotranspiration values for periods of several days, weeks, months and for the growing season, double mass curves were used as shown in Figs. 1 and 2.

In Fig. 1, the accumulated values of daily evapotranspiration, by 5-day periods, from the van Bavel curves (1), are plotted against comparable measured values from lysimeter Y102C for the period May 1 to August 31, 1956. By the end of May the van Bavel calculated values totaled 3.03 in. as compared with lysimeter measured total of 5.38 in. The "line of equal values" or a 45-deg line is given as a

. . . Lysimeter Checks

basis of comparison. The slope of the van Bavel line in May is steeper than this 45-deg line. A factor of 1.7 applied to the van Bavel values for May would bring its total to nearly 5.29 and the slope of this double mass curve for May would approach 45 deg. For the remainder of the growing season, a factor of 1.5 appeared to give the best results. This will be discussed later.

An adjustment factor of 1.5 for June, July, and August, with special consideration given to periods of about 10 days after hay cutting, brought this double-mass curve line into fairly close agreement with the "line of equal values." It is apparent that the empirical formulas cannot take into consideration the reduced rates of evaporation prevailing for a few days after cutting and removal of the hay crop in June and July. The lysimeter measurements which show a sharp drop in the rate of moisture consumption in this period provide a means of further adjustment to the empirically derived values. This factor is 0.6 and can be applied to the daily values for 10 days after hay cutting.

When all the adjustment factors are applied (1.7 for May and 1.5 for June, July, and August and further factor of 0.6 for June 7-16 and for July 19-28) the four-month evapotranspiration totaled 22.04 in. That measured was 21.93 in.— a fairly close agreement.

It is interesting to note that the simplified van Bavel curve approximates the 45-deg line more closely than the more detailed method. The slope of the simplified line for May and August is steeper than the 45-deg line. An adjustment factor of 1.2 applied to data for these two months raises them to values identical to the June and July values (Table 1). In other words, there does not seem to be any difference in the simplified values for the four months, May, June, July or August, for this crop and for this year. It appears desirable to apply a further adjustment factor of 0.6 to the simplified values for 10-day periods after hay cutting. These factors realign the double-mass curve closer to the line of equal values throughout the entire period.

In Fig. 2, the accumulated values of daily evapotranspiration by 5-day periods from the van Bavel curves (1) are plotted against measured values from lysimeter Y102C for the period May 1 to August 31, 1953. (Daily sunshine percentage and temperature values were used to derive the van Bavel detail values. The sunshine values were used in 1953 to select the climate adjective for the simplified method; low, 0-35 percent sunshine; medium, 36-65 percent; and high, 66-100 percent.) This was the corn year for the crop rotation lysimeters. The land surface was mostly bare in May and June. Transpiration was low because of the small leaf area. Evaporation varied according to the wetness of the soil surface — a dry soil losing very little water by evaporation.

It is possible that the authors of empirical formulas for estimating evapotranspiration did not intend that they be used without modification for periods with little or no vegetal cover like that of May-June, 1953. Some users may overlook the fact that evapotranspiration in this period may differ greatly from the estimated. To help emphasize this point, evapotranspiration values were estimated for this period and compared with measured quantities.

Variations between the calculated evapotranspiration and that measured on the lysimeter reflect variations in soil-

TABLE 3. MONTHLY EVAPOTRANSPIRATION (MEASURED AND DERIVED) VALUES FOR IRRIGATION SEASON, SECOND-YEAR ALFALFA-TIMOTHY MEADOW (1956)

Method	Evapotranspiration, in. May	June	July	August	Total
Measured:					
Lysimeter Y102C	5.38	5.29	5.09	6.17	21.93
Derived:					
Blaney-Criddle	4.72	5.52	5.68	5.28	21.20
van Bavel	3.03	4.21	4.06	4.09	15.39
" " (simplified)	4.40	6.00	5.72	5.03	21.15
" " (adjusted)*	3.73	5.58	4.91	4.99	19.21
Thornthwaite	3.32	4.73	5.16	4.81	18.02

*Adjusted for mean air saturation-deficit difference between Raleigh, N. C., and Columbus, Ohio; factor = 1.2.

surface moisture and the development of leaf area of the corn plants (Fig. 2). The van Bavel values and the lysimeter values for May were almost identical. Rainfall for this month was frequent and in fairly large amounts, which kept the soil surface moist. Evaporation was, therefore, near its maximum for the climate experienced. Rainfall for June was much less and the actual evaporation was much lower than the calculated values. Here the van Bavel line departs very noticeably from the 45-deg line. With the development of a more complete vegetal canopy, the van Bavel method appears to underestimate evapotranspiration as shown by the increased slope of the line in Fig. 2. A factor of 1.3 applied to the van Bavel July and August values and a factor of 0.6 applied to the June values adjusts the calculated four-month total from 19.32 to 20.49 in. as compared with 20.08 in. measured. Although the grand total changed but little, the curve more closely coincided with the "line of equal values" throughout the entire period. Adjusted and measured accumulation values were as follows:

Month	Accumulated evapotranspiration (inches) by Van Bavel	Adjusted	Measurement
May	3.50	3.50	3.30
June	8.76	6.64	6.54
July	14.19	13.83	13.34
August	19.32	20.49	20.08

The van Bavel simplified values for corn in 1953 (Fig. 2) deviated more widely from the measured values during May and June than those calculated from the van Bavel curves (1). During July and August, with full vegetal canopy, the "simplified" line parallels the 45-deg line. This indicates little or no difference between the measured values and those estimated by the simplified method. Adjustments were therefore necessary for only the wet May (0.7) and for the fairly dry June (0.5).

Monthly values of evapotranspiration as measured at Coshocton and as estimated by van Bavel (1), Blaney-

TABLE 4. MONTHLY EVAPOTRANSPIRATION (MEASURED AND DERIVED) VALUES FOR IRRIGATION SEASON, CORN (1953)

Method	Evapotranspiration, in. May	June	July	August	Total
Measured:					
Lysimeter Y102C	3.30	3.24	6.80	6.74	20.08
Derived:					
Blaney-Criddle	5.12	5.76	6.00	5.60	22.48
van Bavel	3.50	5.26	5.43	5.13	19.32
" " (simplified)	4.86	6.33	6.77	5.71	23.67
" " (adjusted)*	4.20	6.31	6.52	6.16	23.19
Thornthwaite	4.05	5.16	5.52	5.12	19.85

*Adjusted for mean air saturation-deficit difference between Raleigh, N. C., and Columbus, Ohio; factor = 1.2.

TABLE 5. MEASURED* VALUES OF DAILY EVAPOTRANSPIRATION FOR DAYS JUDGED TO BE DULL, NORMAL OR BRIGHT BY MONTHS, MAY - AUGUST, 1956

Judgment of daily climate	Measured daily evapotranspiration (inch)							
	May		June		July		August	
	Average	Range	Average	Range	Average	Range	Average	Range
Dull - cloudy	0.11	0.0 -0.23	0.10	0.11-0.15	0.11	0.03-0.22	0.13	0.08-0.21
Normal	0.21	0.15-0.28	0.19	0.10-0.23	0.14	0.09-0.18	0.18	0.05-0.22
Bright - hot	0.22	0.14-0.30	0.21	0.07-0.33	0.23	0.13-0.33	0.23	0.18-0.28

*Lysimeter Y102C

Criddle (4) and Thornthwaite (3) for 1956 and 1953 appear in Tables 3 and 4. An adjustment factor to take care of normal atmospheric-moisture differences between Raleigh, N. C., and Columbus, Ohio, was applied to the van Bavel values. It seemed to the author that, if the van Bavel method gave good estimates at Raleigh, N. C., and if estimates for other sections of the country differed noticeably from field measurements, one might modify these estimates by normal air saturation-deficit differences between the locations. A simple arithmetic adjustment factor in this case of 1.2 seemed to improve the monthly estimates somewhat, except for the bare-land condition of the May and June corn year, 1953.

The van Bavel simplified method involves on-the-spot personal judgment of the daily climate. This judgment was recorded in 1956 and estimates of evapotranspiration made (1). Later these were compared in Table 5. Van Bavel values appear in Table 1.

Summary

Empirical methods for determining evapotranspiration values should make it possible to use our water resources more efficiently and to obtain the maximum crop production. Some of the more recently developed methods have been used at Coshocton, Ohio, and their estimates compared with lysimeter measurements of evapotranspiration. The results are encouraging, both from the standpoint of the apparent accuracy of these present methods and of the possibility of developing adjustments for improvement where desirable and practical.

Whereas the application of some empirical methods results in over-all seasonal totals close to the measured values, it appears that some of the monthly values differ too much for some uses. This is especially noticable where bare ground is involved. It is believed that this variation, as well as the reduction in rate of evapotranspiration for several days after hay cutting, can be incorporated into the empirical methods.

With more research and study on this problem, we can look for further improvement in methods of estimating evapotranspiration — an important factor in many water-management programs.

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2 Thornthwaite, C. W. An approach toward a rational classification of climate, The Geogr. Rev. 38: 55-94, 1948.

3 Blaney, H. F. and Criddle, W. D. Determining water requirements in irrigated areas from climatological and irrigation data, USDA SCS TP-96, Washington, D.C. 1950.

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. . . Subsurface Drainage

(Continued from page 93)

Five-year-old mole channels amply demonstrated a summation of the biological and physical factors causing failure. A slight cleavage plane rather than a blade slit was observed, little open channel could be found, and the boundary between channel and subsoil was difficult to distinguish. Analysis of the channel fill material gave no clear-cut picture of its origin. However, it was much more porous, contained three times as much root growth, and lacked the blocky structure of the surrounding subsoil. The effectiveness of mole drains in such a state of deterioration would be very difficult to determine.

Using field investigations as a basis for indicating the causes of failure, a channel-lining machine was designed which would prevent the fall of soil into the channel and provide backfill for the slit, while remaining within limits compatible with the prime objective of lowering cost of drainage. A model was constructed to represent the one-inch mole slit and various plastic and metal materials in a number of shapes were considered. Through preliminary evaluation of shapes and materials, a plastic arch proved most feasible. The experimental prototype used for the mole lining is shown in Fig. 1.

The plastic material, a .015-in. thick by 6-in. wide rigid vinyl strip, was formed into a tight U and fed down through the chute into the mole channel. The plastic had to be cut into 2-in. fingers 2½ in. long to travel from its vertical to its horizontal position. The slits between the fingers lay in a straight line across the sheet in order to avoid stresses transverse to the direction of travel through the 90-deg transition. Such stresses are capable of breaking the plastic sheet. After the plastic sheet completed the transition, its shape was altered, as it left the lining machine, to form an arch approximately 2 in. wide and 2½ in. high.

Originally the model was designed with a wheel to minimize the friction forces of the 90-deg transition. Tension tests showed an 11½-lb pull was necessary to place the material in the channel. When the wheel was replaced by a slide, it was found to require 17 lb pull. Since the continuous strip between the fingers has an ultimate strength of over 120 lb, the slide was adopted to further simply the machine.

The construction of an experimental prototype included a chute for the entry of coarse sand above the plastic to help

(Continued on page 103)

Aeration of Grain in Vertical Bins

F. W. Rabe
Member ASAE

ONE of the primary objectives of grain aeration is to reduce the temperature of the grain. In addition, aeration controls moisture migration, inhibits mold development, preserves initial quality of the grain, removes odors, gives freshness to the grain, and reduces the respiration rate. In general, aeration obviates the usual practice of turning the grain. The rate at which the grain is to be cooled and the depth at which the grain is stored are deciding factors governing the design and the cost of the aeration equipment.

The amount of aeration air is sometimes governed by the time required to cool the grain. For example, it has been found that it requires approximately 90 hr to cool grain to a close approach of the average ambient air temperature when air is circulated at a rate of 0.1 cfm per bushel. In Texas the minimum design standard has been set at 0.1 cfm of aeration air per bushel of grain. For grain holding-bins aeration rates of 0.3 to 0.4 cfm per bushel have been used. Also there are cases on record where considerably less than 0.1 cfm per bushel has given satisfactory aeration results. Robinson, Hukill and Foster* report on results of mechanical ventilation or aeration of corn with air rates varying from 0.25 to 1.2 cfm per bushel. Tests made by the U. S. Department of Agriculture in Texas, to determine the time required to cool an entire bin of grain, indicate that the cooling time T (hr) varies inversely as the air-flow rate, R (cfm per bu). This may be expressed as

$$T = k/R$$

Fig. 1 shows this relationship with the factor k having a value of 9. Also shown is a general approach characteristic of the grain temperature to the ambient air temperature. An analysis of this relationship indicates that the weight of air necessary to cool a bushel of a specific grain to a temperature approaching that of the surrounding atmosphere is a constant for a given location, atmospheric conditions, and moisture content of the grain. Based on the USDA tests and assuming an average cooling air temperature of 60 F and relative humidity of 70 percent, the value of this constant is 40.7 lb. It is interesting to note that during the aeration period most of the grain cooling was caused by the cooling effect of the water evaporated from the grain. The heat removed from the grain, due to sensible heat transfer between the air and grain, accounts for a smaller fraction of the total heat removal necessary to reduce the grain temperature. This of course indicates that during the grain cooling or aeration period there is a slight reduction in the moisture content.

Depth of Grain

The depth of grain through which air has to be moved has a direct and important bearing on the fan power re-

*Mechanical Ventilation of Stored Grain, by R. N. Robinson, W. V. Hukill and G. H. Foster, AGRICULTURAL ENGINEERING, November 1951.

A summary of this paper was presented at a grain storage meeting at the Texas School of Technology, Lubbock, February 1957.

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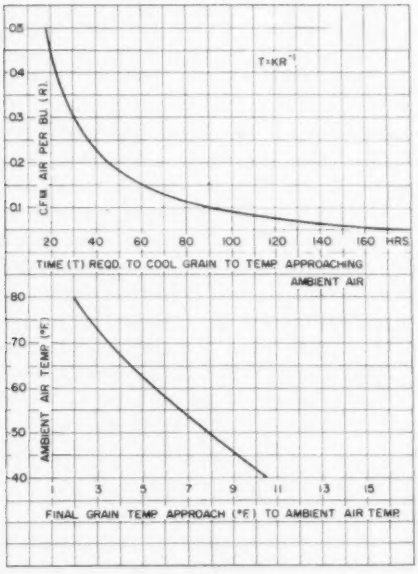

Fig. 1 Grain cooled by means of aeration

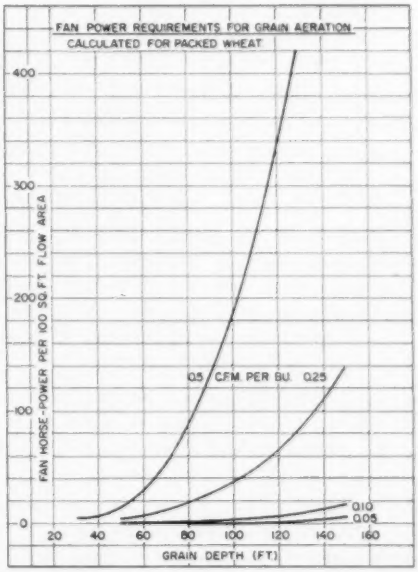

Fig. 2 Minimum fan power requirements for grain aeration calculated for packed wheat

Pressure drop of radially flowing air in grain immediately surrounding half-round ducts in a rectangular bin requiring vertical aeration is studied and an analysis for determining such drop is derived

quirement. Fig. 2 shows the fan power for various air rates per 100 sq ft of flow-area plotted against grain depths. For instance, in a 10-ft square bin with grain 30 ft deep, the power required to operate the fan, when air is circulated at a rate of 0.5 cfm per bu, is 3.4 hp. If the grain is 130 ft deep, the fan power becomes 430 hp. These power requirements are based on air-pressure losses through the grain only and on a uniform air velocity. In actual practice there are duct losses and additional losses through the grain as the air approaches collectors or tunnels which may be located at or near the bottom or along the vertical sides of the bin. Usually the surface area of these collectors is considerably less than the cross sectional area of the bin in the direction of the air flow. The ratio of these areas shall be referred to as the velocity ratio or ϕ. If ϕ is 100 percent, the velocity of the air through the grain may be considered constant. If ϕ is 10 percent, the apparent velocity of the air through the grain near the collector surface will be 10 times greater than the air velocity near the top of the grain mass. This means that the unit air-pressure drop through the grain, surrounding the collector, will be greater than the corresponding pressure drop near the surface of the grain.

In the paper entitled "Radial Air Flow Resistance of Grain," W. V. Hukill and N. C. Ives† have given an excellent analysis of the procedure required to calculate the air-pressure loss for radial flow. This procedure with some modifications‡ was used in determining the fan power, for various values of ϕ, required to aerate 100,000 bu of wheat stored in a bin 29 x 29 x 150 ft high. An air flow of 0.1 cfm per bushel was assumed. Fig. 3 shows that for these conditions the fan requires 144 hp when ϕ is 100 percent. When ϕ is 0.0785, the necessary fan input is 198 hp. These relative power requirements are based on vertical air flow. If the air flow is horizontal and the grain depth in the direction of air flow is 28 ft and ϕ is 10 percent (based on the maximum vertical flow area), the fan requires only 9.2 hp to circulate the same amount of air. The foregoing emphasizes the importance of *(a)* the air circulation rate, *(b)* the grain depth in the direction of the air flow and *(c)* relative surface area of the air collector, in establishing the power required by aeration fans.

To assure uniform air flow through the grain, the external collector area per foot of length, should be constant. Actually, this area should increase slightly in proportion to the pressure drop of the air within the collector and in a direction away from the fan. Unless the air velocities in the collector or aeration duct are excessive and the collector is very long, the pressure drop of the air within this enclosure may be neglected. It is evident that, for a given installation, the effective external surface of an aeration duct influences the amount of air circulated. The aeration rate decreases as this area is decreased.

†AGRICULTURAL ENGINEERING, May 1955.

‡Appendix.

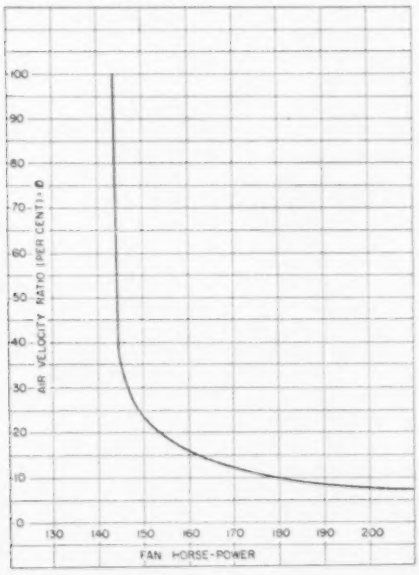

Fig. 3 Air collector surface vs fan power requirements (grain bin, 29 x 29 x 150 ft; capacity, 100,000 bu of wheat; 10,000 cfm aeration air; vertical air flow). Fan horsepower is 178 for vertical air flow when ϕ is 10 percent; 9.2 for horizontal air flow when ϕ is 10 percent

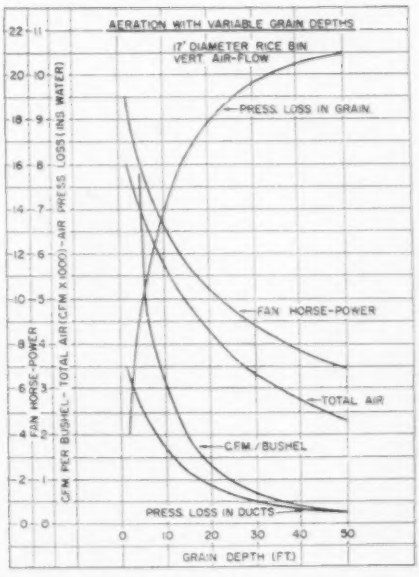

Fig. 4 Aeration with variable grain depts (17-ft diameter rice bin for vertical air flow)

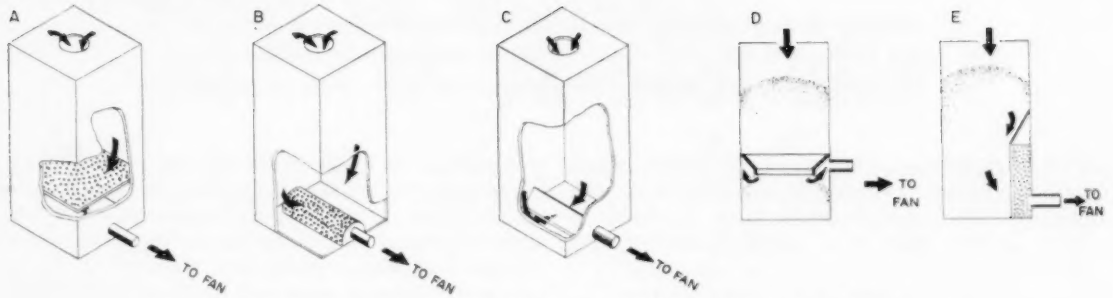

Fig. 5 Types of air collectors that have been used for vertical aeration in high bins

High Bins

The power required to move air through grain, stored in high bins, may become inordinate. For this reason, considerable attention has been given to moving the aeration air horizontally through the grain if the bin diameter or width is less than its height. There are some fundamental differences in the equipment design for vertical and horizontal flow (cross flow) aeration systems. The former is usually the less expensive and can function without special controls regardless of the grain level in the bin. Horizontal aeration requires two collectors having a combined length of approximately twice the height of the bin. In addition special controls or valves must be provided to regulate the air flow when the bin is partially filled with grain. The final selection between the two systems will, in most cases, be based on cost considerations. There are cases where horizontal air flow is the only answer; as an example, consider aeration of grain stored in a 20-ft diameter bin 150 ft high with 0.5 cfm of air per bushel. In this case the power required by the fan, for vertical aeration, would be prohibitive.

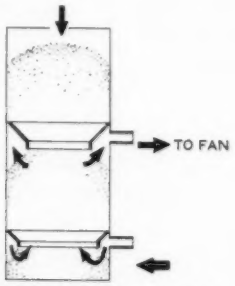

Fig. 6 Two cone-type collectors installed in a bin. This system requires less than one-fourth of the power required for similar installations such as shown in Fig. 5

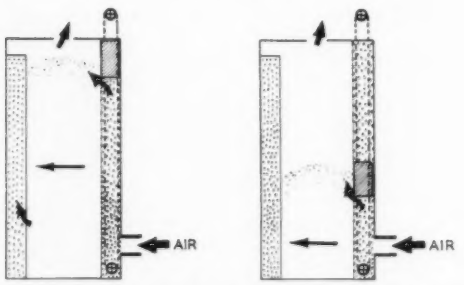

Fig. 7 Typical cross-flow aeration systems. Fig. 7a *(left)* consists of collector ducts, usually half round and constructed of perforated metal or metal louvers, fastened vertically to the inside of opposing bin walls. Fig. 7b *(right)* illustrates a movable valve for controlling air flow when the bin is partially filled with grain

High Static Fans

For relatively high static fan pressures, radial-blade fans are often used. These fans have a rising power characteristic. In a vertical aeration system provided with such fans, the fan power increases as the grain level in the bin decreases. The curves shown in Fig. 4 are based on the characteristics of a radial-blade fan and show the comparative relationship of the grain depth, in a given bin, to the *(a)* fan power, *(b)* total air circulation, *(c)* cubic feet per minute per bushel of grain and *(d)* air pressure losses when the air is drawn or forced vertically through the grain when $\phi =$ 100 percent.

In the case of horizontal air flow, and with suitable air-control devices, the power required to operate such a fan decreases as the level of the grain in the bin decreases. As a practical illustration and for vertical aeration at 0.1 cfm per bushel, it requires 20 hp to aerate 100,000 bu of wheat, stored at a depth of 50 ft. If the grain depth is 100 ft, it would require 85 hp to operate the fan. For similar conditions, but with horizontal or cross air flow, the respective fan power requirements would be approximately 10 hp and 4 hp. The fan power will remain substantially constant, regardless of the grain level, if an axial flow-type fan can be used for either vertical or horizontal aeration. For vertical air flow the total amount of air increases as the grain level decreases, and for horizontal air flow it decreases as the grain level decreases. In either case the air flow rate (cfm per bu) increases as the grain level in the bin decreases. This rate of increase is much greater for vertical than for horizontal air flow.

Design for Air Flow

From the foregoing it is evident that the design of an aeration system for a specified performance requires a thorough knowledge of fan characteristics and of the basic laws pertaining to air flow. Today the grain industry often designates the air flow rate required by an aeration system. For instance, two similar storages may require different rates of aeration air flow such as 1/20 and 1/5 cfm per bu. It is obvious that the fan and collector duct designed for one of these conditions will not always meet the requirements of

the other condition. This point is pertinent because aeration equipment is sometimes selected only on the basis of the amount of grain to be aerated regardless of air-flow rates or grain depths. Those who want to aerate grain should determine and specify the amount of aeration air required. If the time element is a factor in cooling grain, then the aeration rate can be determined with reasonable accuracy. If only "aeration" is wanted, then a minimum air flow rate for different localities and perhaps different grains should be established.

There are many so-called aeration systems as the result of haphazard designs. A contributing factor toward such designs is misinformation on aeration which has been indiscriminately published and otherwise disseminated to the grain-storage industry by unqualified trade representatives. As an illustration, a recent article which appeared in a grain magazine states unqualifiedly that a fan, driven by a 2-hp motor, aerated 333,000 bu of grain at a rate of 0.25 cfm per bu. The grain was stored at a depth of 54 ft. To handle air at the conditions set forth requires approximately 350 hp instead of 2 hp. There are numerous aeration installations which, because of inadequate air-collector surface area and small air pipes, are equipped with fans driven by high powered motors. Even with this overpowered fan equipment only a relatively small amount of aeration air is sometimes circulated. There are other installations which have inadequate fan capacity to handle the amount of air considered necessary for aeration. Many difficulties have also been experienced with fans which are built by artisans unfamiliar with fan design. In most cases such fans have never been tested and their ratings are not in accordance with the standard test code nor conform with U. S. Department of Commerce commercial standards for centrifugal and axial fans.

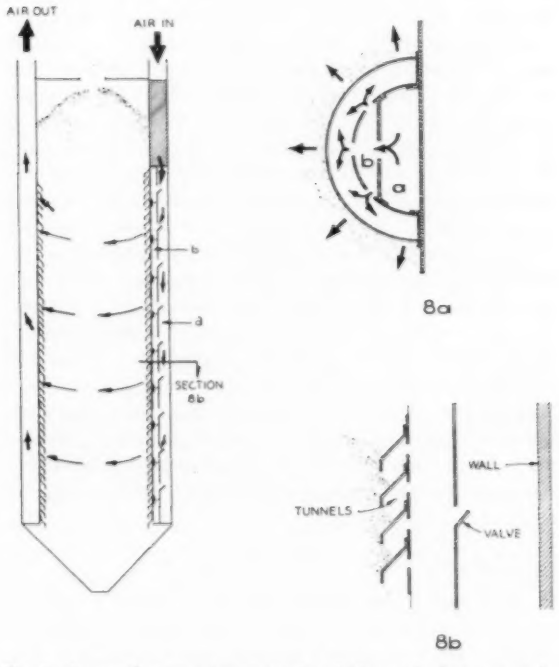

Fig. 8 A cross-flow aeration system in which supply ducts are made by fastening a metal partition to the walls of a half-round duct (Fig. 8a). Air is discharged into *(a)* from where it flows through valved openings into compartments in *(b)*. From here it passes through holes in the subtended periphery of space *(b)* to tunnels formed by the louvers and the grain at its angle of repose (Fig. 8b)

Air Collectors

Some types of air collectors, which have been used for vertical aeration in high bins, are shown in Fig. 5 (A, B, C, D, E). In order to limit the air-pressure loss within the grain, collectors should be so designed that the air velocity at the collector surface is approximately 30 fpm or less. The loss of air pressure through the perforations of this type of collector may be neglected if the area of the perforations is as little as 8 percent of the effective surface area and the air velocity at the collector surface is within the specified limitations. The *inverted-trough* and *cone*-type collectors require no obstructions, such as metallic perforations or screens, to prevent grain from entering the airstream to the fan, provided that the cross sectional area bounded by the collector surface and the projected grain surface, at its angle of repose, limits the maximum air velocity in this space to roughly 1500 fpm.

Fig. 6 shows two cone-type collectors installed in a grain bin. One collector is located near the bottom and the other at the center of the bin. The bottom and smaller collector is used to supply or discharge one-half or more of the required aeration air depending upon the level of the grain in the bin. The center collector supplies or removes all of the aeration air. When the bin is filled with grain and the fan discharges air from the grain to the outside, one-half of the aeration air enters at the bottom collector and the other one-half enters through a suitable opening, such as a manhole, at the top of the bin. If the bin is only partially filled, means for modulating the air flow at the top inlet should be provided so that a uniform aeration rate can be maintained through the grain mass. With this type of system

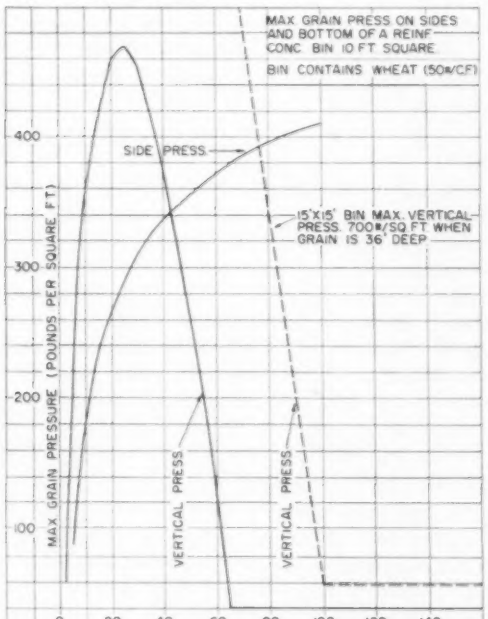

Fig. 9 Maximum grain pressure on sides and bottom of a reinforced concrete bin 10 ft square. Bin contains wheat (50 lb per cu ft)

the required fan power is less than one-fourth of the power required for similar vertical-flow installations such as shown in Fig. 5.

Figs. 7 and 8 illustrate typical cross-flow aeration systems. The advantage of this design over the conventional vertical-flow installation, particularly for high bins and above average aeration rates, is the comparatively low fan power requirement. The arrangement for cross-flow aeration (Fig. 7a) consists of collector ducts, usually half round and constructed of perforated metal or metal louvers, fastened vertically to the inside of opposing bin walls. One collector supplies the air and the other removes the air from the grain. In this case the fan is shown located at the bottom of the bin and discharges air to one collector which is provided with a movable-type piston valve. The duct on the opposite wall collects the air after it has passed through the grain. From here it is discharged to the atmosphere at any convenient point. If the bin were completely filled with grain a movable valve would not be required; however, a section of the upper part of the collector would have to be blanked off to prevent by-passing of the air at this point. It is evident that the function of the movable valve is to control the air flow when the bin is partially filled with grain (Fig. 7b).

In some instances the top of the bin or headhouse offers the only available place for the location of the fan and air vents. The cross-flow aeration system (Fig. 8), is designed to meet this requirement and also to control the air flow at variable grain levels in the storage bin. Here, as in the previously described cross-flow design, both supply and exhaust ducts are secured vertically to opposing bin walls. The stipulated condition, of fan and vent location, requires that two ducts or the equivalent be installed at the fan. The fan may push or pull air through the grain. If the air is pushed, the fan discharge is connected to one of the two supply ducts. In this case the supply ducts are made by fastening a metal partition to the walls of the half-round duct (Fig. 8a). This partition, like the chord of the arc of a circle, divides the area of the half-round duct in such a manner that the area "a" is considerably larger than area "b". Air is discharged into "a" from where it flows through valved openings into compartments in "b". From here it passes through holes in the subtended periphery of space "b" to tunnels formed by the louvers and the grain at its angle of repose (Fig. 8b). These tunnels or hollow spaces extend completely around the periphery of the half-round duct. The advantage of using louvers instead of perforations for distributing air from the duct to the grain is apparent.

Louvers also add structural strength to the duct and obviate the need for screens or perforations to keep grain from entering the ducts. At partial-bin loadings, air could by-pass from one compartment to another in which the air valve is closed. To prevent excessive air leakage under such conditions a small number of louvers are blanked off at the top and bottom of each compartment. This provides a modified labyrinth packing in the form of a column of grain of depth equal to the depth of the obstructed louvers.

An Installation

To aerate 20,000 bu of wheat, stored in a bin 100 ft high and approximately 18 ft in diameter at a rate of 0.5 cfm per bu, a cross-flow multiple-compartment aeration system was selected. The aeration equipment was so proportioned that the air-pressure loss in the ducts and in the grain immediately surrounding the ducts was roughly equal to the pressure drop through the grain only if $\phi = 100$ percent. Calculations indicate that the total static pressure against which the fan must operate, at full load conditions, to meet the required performance, is approximately 8.5 in. of water. For the same conditions, but with vertical air flow, the air-pressure loss through the grain only is nearly 200 in. of water. For this particular design the diameter of the half-round supply and exhaust ducts was 38 in. and the diameter across the louvers 42 in. Considerably higher air velocities were used than those previously recommended. However, the increased fan power due to higher duct losses resulting from these air velocities seems justified by the lower costs of smaller aeration ducts.

Air-collector ducts located at the bottom of the bin are subject to the vertical pressure of the grain at that point. Ducts located on the side of the bin have to withstand the side or horizontal pressures of the grain. The greatest weight of grain which is carried by friction on the walls of the bin equals the total weight of the grain in the bin less the weight of a pyramidal mass of grain (in case of circular bins this is a conical mass) at the bottom with sides sloped at the angle of repose of the grain. This pyramidal mass cannot be carried by friction between the grain and the walls. The weight of grain carried at the bottom increases as the depth of grain increases until a point is reached where the grain pressure at the bottom of the bin has reached a maximum. An increase in the depth of grain beyond this point decreases the weight of grain carried on the bottom until the grain carried by friction on the walls has reached the described maximum. Fig. 9 shows this relationship for a 10×10-ft reinforced concrete bin as calculated according to W. Airy's formulas. The maximum side or horizontal pressure is also plotted against the grain depth. This pressure curve increases rapidly as the bin is filled with grain and then becomes asymptotic. The smoother the bin, the greater are the horizontal and vertical pressures on the bin walls and bottom. In the design of either horizontal or vertical air-collector ducts, the effect of grain pressures must be considered. The foregoing shows that equivalent hydrostatic pressures, due to a liquid of the same density as the grain which is to be stored, cannot be used to determine the maximum compression loads for which the ducts must be designed.

Appendix

Tests have shown that, for the same external air collecting or distributing surface exposed to the grain, the effective or active area of a round collector is less than that of a half-round collector duct. This is true if round collector ducts are fastened directly to the bin floor or wall and are therefore not completely surrounded by a depth of grain in which air is assumed to flow radially. Many air-collector

ducts, as now installed, are of the half-round type. For this reason the following analysis, to determine the approximate pressure drop of radially flowing air in grain immediately surrounding the duct in a rectangular bin and for vertical aeration, applies to half-round collector ducts. With some modifications this analysis is applicable to other types of collectors. For radial air flow in cross-flow aeration and for circular bins a more exact mathematical relationship to determine the air-pressure loss can be derived. The derivation of such an analysis is beyond the scope of this article. For circular bins and vertical aeration a reasonably close approximation of the air-pressure loss during radial flow may also be obtained by the method here described.

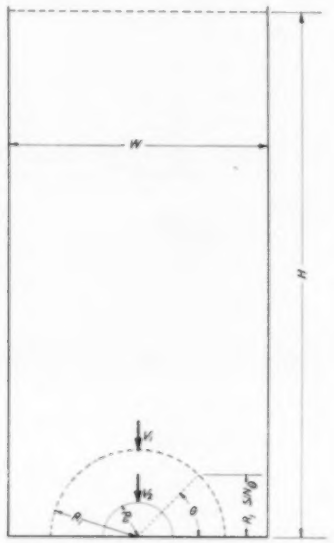

Fig. 10 Analysis for determining approximate pressure drop of radially flowing air in grain immediately surrounding the duct in a rectangular bin and for vertical aeration

M = total air flow (cfm)

W = width of bin (ft)

L = length of bin (ft)

H = depth of grain in bin (ft)

Q = air flow per ft length of collector duct (cfm)

R_0 = radius of half round collector duct (ft)

R_1 = radius which defines the area through which the air pressure loss is to be determined (Assume $R_1 = W/\pi$)

V_1 = apparent air velocity at $R_1 = M/LW$ (fpm)

V_2 = apparent air velocity in the grain at the surface of the collector duct $= V_2/\phi$ (fpm)

P_1 = PRESS LOSS OF AIR PER FOOT OF GRAIN DEPTH AT VELOCITY V_1 *

P_2 = PRESS LOSS OF AIR PER FOOT OF GRAIN DEPTH AT VELOCITY V_2 *

P = PRESS LOSS OF AIR IN GRAIN BETWEEN R_1 AND R_0

P_t = TOTAL PRESS. LOSS OF AIR THROUGH ENTIRE GRAIN MASS = $P_t(H - R_1 \sin\theta) + P$ **

THE GENERAL RELATIONSHIP BETWEEN PRESSURE LOSS AND RATE OF AIR FLOW IN GRAIN MAY BE EXPRESSED AS

$$P = kV^x$$

AND

$$\frac{P_1}{P_2} = \left(\frac{V_1}{V_2}\right)^x$$

FROM SHEDD'S DATA P_1 AND P_2 CAN BE DETERMINED FOR VALUES OF V_1 AND V_2

THEN

$$x = \frac{\log \frac{P_1}{P_2}}{\log \frac{V_1}{V_2}} \quad \text{AND} \quad k = \frac{P_1}{V_1^x}$$

$$dP = kV^x\,dR \quad \text{SINCE} \quad V = \frac{Q}{\pi R}$$

$$dP = k\left(\frac{Q}{\pi R}\right)^x dR = \frac{kQ^x}{\pi^x} R^{-x}\,dR$$

$$P = \int_{R_0}^{R_1} \frac{kQ^x}{\pi^x} R^{-x}\,dR = \frac{kQ^x}{\pi^x}\left[\frac{R^{1-x}}{1-x}\right]_{R_0}^{R_1}$$

$$P = \frac{kQ^x}{\pi^x(x-1)}\left[\frac{1}{R_0^{x-1}} - \frac{1}{R_1^{x-1}}\right]$$

* RESISTANCE OF GRAINS AND SEEDS TO AIR FLOW – C. K. SHEDD

** ASSUME $\theta = 45°$

. . . Subsurface Drainage

(Continued from page 97)

maintain a porous passage from plow depth to the drain. The lining machine was adapted to fit behind an experimental mole plow designed by the Caterpillar Tractor Co. to be drawn by their Model D-4 tractor (Fig. 2). It was hinged to allow the moderate amount of play that is required for shallow curves and minor soil irregularities.

This machine made its initial runs in the summer and fall of 1956. Cost calculations indicate that a price of 7 cents per foot, 4½ cents of which is for plastic material, should cover the operation. An operating speed of 1½ mph was successfully used, and a replicated experiment installed to evaluate the drain's performance. Preliminary testing, after nine months, indicates the lined mole drain to be in better condition than the unlined moles of the experiment.

The immediate application potential of the drain in its present form is for short laterals to outlet ditches and supplementary laterals to existing tile lines. By virtue of the reduced cost and simplicity of installation, drainage may also be possible on lands that can not justify the cost of conventional subsurface drainage. Looking toward the future, additional low-cost methods are being considered to produce a completely closed perforated conduit having all the advantages of the present method of installation and its related lowered costs. Such a drain will eliminate the problems of highly erosive soils, steep slopes and quick conditions left unsolved by the present plastic arch.

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Elected to Life Membership

The Council of ASAE during its winter meeting sessions in December conferred upon the following members the grade of Life Member: G. C. Neff, M. L. Nichols, and I. D. Wood.

Grover C. Neff is one of the nationally recognized early pioneers of rural electrification who contributed a great deal to the sound progress in that field which began in the early 1920's. He was one of the organizers and for many years chairman of the national Committee on the Relation of Electricity to Agriculture, the first organized, cooperative national effort to develop farm use of electric power. He became a member of ASAE in 1923 and was instrumental in the organization of its Rural Electric Division.

A native of Milford, Ind., Mr. Neff graduated with a B.S. degree in civil engineering from Purdue University in 1907, and was awarded a professional C.E. degree in 1911. He retired in 1954 as president of the Wisconsin Power and Light Co., a position he had held since 1933. He had served the company and its predecessors for 46 years and continued as chairman of the board of directors after his retirement.

In 1946-47 he served a term as president of the Edison Electric Institute. He was honored with a Distinguished Service Citation from the University of Wisconsin in 1951, and in 1952 wth an honorary doctor's degree from Purdue University.

Mark L. Nichols, past-president of ASAE, becomes a Life Fellow. He was born near Bellevue, Ohio and graduated from the Bellevue High School. He received a B.S. degree in agricultural engineering from Ohio State University in 1912, an M.S. degree in soils from Delaware University in 1916, and an honorary Sc.D. degree for soils research from Clemson College in 1937. His academic training also includes special engineering courses at the Alabama Polytechnic Institute.

He has a background of experience and accomplishment in the field of agricultural research and soil conservation. He developed the program of research in soil dynamics at Auburn and helped set up the National Tillage Laboratory. He organized the agricultural engineering department at Auburn, of which he was head from 1919 to 1935. He was chief of research for SCS from 1938 to 1953, and has served as director of the National Tillage Machinery Laboratory since 1953.

Mr. Nichols was a member of the State Board which organized the rural electrification program in Alabama. In 1918 he joined ASAE and has served on the Council, on numerous committees of the Society and was president in 1946-47. He organized the Southern Section of ASAE becoming its first chairman and has since helped direct its activities.

In 1934 he received the McCormick Medal, and in October 1957 a framed portrait of Mr. Nichols was presented during a seminar on tillage and traction equipment research to be displayed in the agricultural engineering building at API, honoring him for his long and distinguished service to agricultural engineering.

Ivan D. Wood, past-president of ASAE now becomes Life Fellow. He has had a long and busy career as an agricultural engineer and has done a great deal in extending to the general citizenship of the nation the value of engineering service.

He received a B.S. degree in engineering in 1912 and an M.S. degree in agricultural engineering in 1913 from the University of Nebraska. He was appointed extension agricultural engineer for Nebraska in 1914 serving in that capacity until 1940 with the exception of service in World War I and two special assignments on irrigation and water conservation with the U. S. Forest Service.

In 1940 Mr. Wood became district and area engineer in the 17 western states for the Farm Security Administration. In 1945 he was appointed irrigation engineer with the SCS and in 1954 federal extension irrigation specialist with headquarters in Denver, Colo. He retired from his work with the federal extension service, USDA, in 1957.

He became a member of ASAE in 1919 and was elected president and received the John Deere Gold Medal in 1952. In 1954 he was the recipient of the honorary degree

ASAE MEETINGS CALENDAR

February 14—WASHINGTON, D. C. SECTION, USDA, South Bldg., Washington, D. C.

February 15 — OHIO SECTION meeting at the New Idea Division of Avco Mfg. Corp., Coldwater, Ohio.

February 18 — NORTH CAROLINA SECTION, North Carolina State College, Raleigh, N. C.

March 14 — WASHINGTON, D.C. SECTION, USDA, South Bldg., Washington, D.C.

March 28-29 — ROCKY MOUNTAIN SECTION, Engineering Center, Colorado State University, Fort Collins, Colo.

March 28-29 — MID-CENTRAL SECTION, Robidoux Hotel, St. Joseph, Mo.

April 2 — CONNECTICUT VALLEY SECTION, University of Connecticut, Storrs, Conn.

April 4 — IOWA SECTION, place not announced.

April 25 — QUAD CITY SECTION, place not announced.

April 25-26 — FLORIDA SECTION, Jacksonville, Fla.

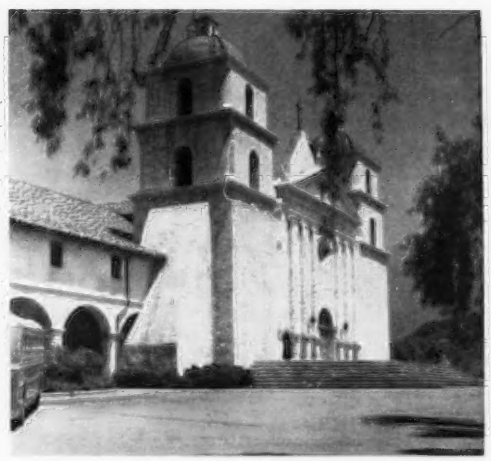
April 26 — OHIO SECTION, place not announced.

June 22-25 — 51st Annual Meeting, Santa Barbara Campus, University of California, Santa Barbara, Calif.

August 25-27—NORTH ATLANTIC SECTION, Guelph, Ontario, Canada.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Make Plans for 1958 ASAE Annual Meeting



(Left) Scene of local interest in Santa Barbara is Old Santa Barbara Mission founded by the Spanish in 1896. *(Right)* Local Arrangements Committee members look over the beach and coeds of the University of California (Santa Barbara Campus) for ASAE Annual Meeting. Committee members *(left to right)* R. L. Perry, J. R. Tavernetti, J. F. Merson, T. E. Bond, L. H. Lamouria, and C. T. Rasmussen

Convention City for ASAE 1958 Annual Meeting

The Southern California resort city of Santa Barbara and the University of California's "campus with a seashore" will be the focus of interest for ASAE members attending the Society's 51st Annual Meeting June 23 to 25.

The "Golden State in '58" program, now being arranged, will include recreational tours of the historic and scenic area for wives and children during the meetings.

Location of the meetings in south coastal California promises to offer a wide variety of tours of engineering interest. These are being arranged to take in packing plants, mechanized ranches, labor camps, frost protection equipment, and other phases of agriculture in the Santa Barbara area.

One off-campus meeting, the Tuesday night barbecue dinner, is being scheduled. The rest will all be on the seashore campus of the University of California Santa Barbara College, located at nearby Goleta.

Santa Barbara is the center of an agricultural district including cattle ranches, vegetable farms, and citrus ranches. At Santa Barbara is one of the best preserved of the chain of Spanish missions that brought civilization to California in the 1700's.

of doctor of agriculture from the University of Nebraska. He was one of three extension agricultural engineers to receive a USDA Superior Service Award in 1956.

Farm Electrification Institute

The New England Farm Electrification Institute was held January 22-24 at the University of Massachusetts, Amherst. General subject matter areas covered were on institute and electrification programs and activities, materials handling on dairy farms, engineering in poultry, fruit and vegetable production and other topics of engineering concern.

Speakers for the first day, January 22, included W. A. Junnila, H. H. Beaty, and W. J. Ridout who discussed the use of electric power to improve rural living. In joining with dairy farmers attending the Dairy Farmers Seminar on Thursday morning, January 23, the electric representatives learned about efficient materials handling from talks by J. P. Schaenzer, R. W. Kleis, and J. W. Zahradnik.

Friday's program emphasized workshop sessions on egg cooling and storage, hay drier design, dairy barn ventilation design, and poultry house ventilation design. J. T. Clayton, W. C. Wheeler, E. C. Schneider and W. A. Junnila were leaders.

EVENTS CALENDAR

February 9-15 — Observance of *National Electrical Week*. The objective will be to create a nationwide spotlight on the contributions of electricity and the electrical industry to our American economy and way of life.

National Water Resources Institute

The National Water Resources Institute will be held March 11-13 in Lincoln, Nebr. Aspects of water resource problems will be studied at a national level. Included in the program will be discussions of water supply and use, water control, water requirements for agriculture, industry and navigation, water conservation, and sectional water problems and policy. Irrigation equipment exhibits will be set up in connection with the Institute.

Complete information on the Institute including programs and reservations may be obtained by writing to National Water Resoruces Institute, Pershing Municipal Auditorium, Lincoln, Nebr.

February 13-15 — Meeting of the National Society of Professional Engineers will be held at Michigan State University, East Lansing.

February 16-22 — *1958 National Engineers' Week* sponsored by the National Society of Professional Engineers.

February 25-26 — Sixth Annual *National Dairy Engineering Conference*, Kellogg Center, Michigan State University, East Lansing. Sponsored by the agricultural engineering and dairy departments. For more details write Carl W. Hall, Agricultural Engineering Dept., Michigan State University, East Lansing.

March 11-13 — *National Water Resources Institute*, Lincoln, Nebr.

March 17-21 — *1958 Nuclear Congress* will be held at the Chicago Amphitheatre, Chicago, Ill. It is managed by the American Institute of Chemical Engineers and coordinated by the Engineers Joint Council and will include the 4th Nuclear Engineering and Science Conference, 4th Inter-

(Continued on page 126)

BEN G. VAN ZEE

G. M. BOWMAN

C. K. KLINE

P. F. TALENTI

N. H. FOOTE

V. E. HANSEN

Ben G. Van Zee announced his retirement as chief engineer, product design, Minneapolis-Moline Co. He started working for the Company in the experimental department on July 1, 1930, and has been associated with them since.

Mr. Van Zee, a native of Iowa, received a B.S. degree in agricultural engineering from Iowa State College in 1922, and an M.S. degree in 1930. Following graduation from college in 1922, he taught in schools at Morning Sun, Iowa, and Mankato, Minn. In 1928-29 he was employed as an agricultural engineer, with major work in drainage, in the Costa Rican division of the United Fruit Co.

While a graduate student at Iowa State College (1929-30) he was employed as a research fellow in agricultural engineering by the Iowa Agricultural Experiment Station.

Mr. Van Zee became a member of ASAE in 1922. He has served as chairman of the Power and Machinery Division and is currently serving as chairman of its Technical Committee. He has been active on other committees of the Society and in the Minnesota Section. He has also been a member of the Society of Automotive Engineers for many years and has played a prominent part in the activities of the SAE Tractor Technical Committee.

Mr. and Mrs. Van Zee plan to spend February and March in Arizona and return to their home in Minneapolis.

•

George M. Bowman has been appointed district sales manager of Minnesota and North Dakota for John Bean Div., Food Machinery and Chemical Corp. He graduated from the University of Minnesota with a B.S. degree in agricultural engineering and has been associated with the John Bean sales organization for four years. He was sales engineer for Kaiser Aluminum Co. in Chicago before joining John Bean Div. in 1953.

•

Cernyw K. Kline was recently appointed extension specialist in agriculture at the University of Kentucky. He will assist county agents, teachers, manufacturers and farmers in solving problems related to agricultural engineering.

Mr. Kline graduated from Michigan State University in 1948 with B.S. degrees in soil science and agricultural engineering. In 1949 he received an M.S. degree in agricultural engineering from Michigan State. He was assistant professor and extension specialist in agricultural engineering at Ohio State University from 1951-1954. More recently he was manager and partner of the Kline Farm Engineering Service at Mendon, Michigan.

•

Pier F. Talenti has been appointed assistant vice-president of the International Banking Dept. for the First Western Bank and Trust Co. of San Francisco, Calif.

A native of Rome, Italy, Mr. Talenti was educated in Europe, attending the University of Rome and obtaining degrees from the I.T.S. School in Fribourg, Switzerland. Before coming to the United States he was engaged in land development and reclamation work with his own firm in Rome. After coming to the United States he attended the University of California (Davis) and received an M.S. degree in agricultural engineering in 1954. He started working for First Western Bank and Trust Co. in 1955.

•

Norman H. Foote, returning to the Long Island Agricultural and Technical Institute in Farmingdale, N. Y., from Israel, has been appointed head of the division of agriculture and ornamental horticulture. Formerly he was head of the agricultural engineering dept. In 1955 he went to Israel as a member of the State University of New York Research Foundation team to aid Israelis in making more efficient use of their farm machinery.

•

Vaughn E. Hansen has been appointed director of the Engineering Experiment Station at Utah State University and elected president of the Intermountain Section of the American Society of Civil Engineers for 1958. Currently he is president of Agricultural Development and Engineering Services, Inc., and professor of civil and irrigation engineering at the University. He has done consulting on irrigation and drainage problems in South America, Europe, Africa and Hawaii.

•

Delbert E. Gentner has resigned his position as soils technician, soils department, Michigan State University, to become an assistant to service manager, Massey-Harris-Ferguson Branch in Lansing, Mich.

•

Glenn E. Stewart has received his discharge from the U.S. Air Force and has returned to his work with Caterpillar Tractor Company.

•

O. C. French, head of the agricultural engineering department, Cornell University, is on a year's leave of absence to serve on the staff of the Cornell-Los Banos project with the College of Agriculture of the University of the Philippines.

Harold E. Gray, also from Cornell University, has just returned from spending 18 months on the above project. The work at Los Banos is concerned with research on irrigation, drainage, rice drying and storage, and small tools. It also consists in aiding the development of the teaching program of the agricultural engineering department at the University of the Philippines.

E. S. Shepardson, associate professor of agricultural engineering at Cornell, is serving as acting head of the department in the absence of O. C. French.

•

Biswa N. Ghosh has resigned as assistant soil conservation officer with the Central Soil Conservation Board, Government of India. He is working as a design analysis engineer in the product engineering dept. of the International Harvester Co., Ltd., and is located at Doncaster, Yorks, U. K.

•

Guy O. Woodward recently joined the Federal Extension Service staff as successor to **Ivan Wood** who retired last June. The headquarters of the Irrigation and Water Management office have been transferred from Denver to Washington, D.C. Formerly Mr. Woodward served for three years as educational director for the Sprinkler Irrigation Association.

Earlier he served for seven years as irrigation specialist in the Wyoming Extension Service and spent eight years in irrigation engineering with two sugar companies. He received a B.S. degree in agriculture from the Utah State University and an M.S. degree in 1952 from the University of Wyoming.

•

L. W. Larson, formerly on the staff of the agricultural engineering dept. of Cornell University, has taken a new position with International Harvester Co. in Chicago as product designer.

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Michigan Section

The Michigan Section will meet February 15 at the Ford Motor Company in Dearborn, Mich. Following registration the morning program consists of papers on sprinkler irrigation development in the Eastern U.S., by J. Rathjens; small watershed studies, by R. Z. Wheaton; a soil value system for agriculture, by M. G. Bekkar; and dynamic tractor stability, by W. F. Buchele.

The theme of the afternoon program is on the training of engineers by industry. The first paper covers trends in engineering education, by K. B. McEachron, Jr.; followed by sales engineering training in a large company, by J. R. Schram. Subjects on training of sales engineers in a small organization, by N. H. Mitchell; practical engineer training within a small organization, by J. P. Carr; and training of research and development engineers in a large organization, by E. L. Yates, are also included. The closing paper is on the creative engineering training program, by W. J. Friess.

Virginia Section

The following officers were elected for the year 1957-58 at a business meeting of the Virginia Section held November 16 at the Virginia Polytechnic Institute in Blacksburg, Va. Chairman, R. J. Blair; vice-chairmen, A. J. Lambert, R. E. Bass and B. L. Parsons; and secretary-treasurer, J. H. P. Mason.

Connecticut Valley Section

The Connecticut Valley Section meeting was held December 5 at Bradley Field, Windsor Locks, Conn. Following a banquet, introductions were made and the meeting was called to order by the Section chairman, Richard Kinner. The speaker for the evening was E. A. Silver, New Holland Machinery Co., who spoke and showed slides concerning the recent developments in research and equipment for forage handling.

Quad City Section

Approximately 140 people, largely representatives of the farm machinery industry, attended a dinner and technical meeting of the Quad City Section held at the Moline American Legion Club, January 10, Moline, Ill.

Leslie Boler of Winnebago, Minn., spoke on advanced farm practices. He told of success in approaching 100 bushel per acre corn on his 600 acres and attributed this success to the combined use of the latest agricultural equipment and chemicals which enables him to raise and harvest his corn crop with only seven field operations.

"What About Corn Picking Contests" was given by Dale Hull in which he evaluated the rules and scoring procedure used in the state and national corn picking contests held annually in the corn belt.

The first 1958 technical series of four meetings sponsored by the Quad City Section was held on January 31 in the Iowa-Illinois Gas and Electric Co. auditorium, Rock Island, Ill. The group of meetings will be on the power transmission phase of product design. The January 31 meeting was on bearings and seals design. Speakers were N. F. Andrews, Deere & Co.; Warren Rasmussen, Chicago Rawhide Mfg. Co.; and George Raley, Fafnir Bearing Co.

Section Project Ideas

The Quad City Section has scheduled a series of four technical lectures to be held during January and February. The chosen theme is "Power Transmission Phase of Product Design." Engineers from seven farm equipment and farm equipment component manufacturers have been selected to speak on bearing and seals design, gear design, V-belt and chain drives design, and clutch design. A similar project was conducted in 1957. For more details see Quad City Section news.

Other meetings in this series are scheduled for February 14, 21 and 28. C. W. Genson, J. I. Case Co., will speak February 14 on gear design; Al Poehlman, Gates Rubber Co., and E. A. Paul, Roller Chain Division, Chain Belt Co., February 21, on V-belt and chain drives design; and Robert Ludwig, Dana Corp., February 28, on clutch design.

Oklahoma Section

A meeting of the Oklahoma Section was held in Stillwater, Okla., December 6, 1957. The program stressed reports in the fields of machinery and structures. Earl D. Anderson, president of ASAE, was the luncheon speaker.

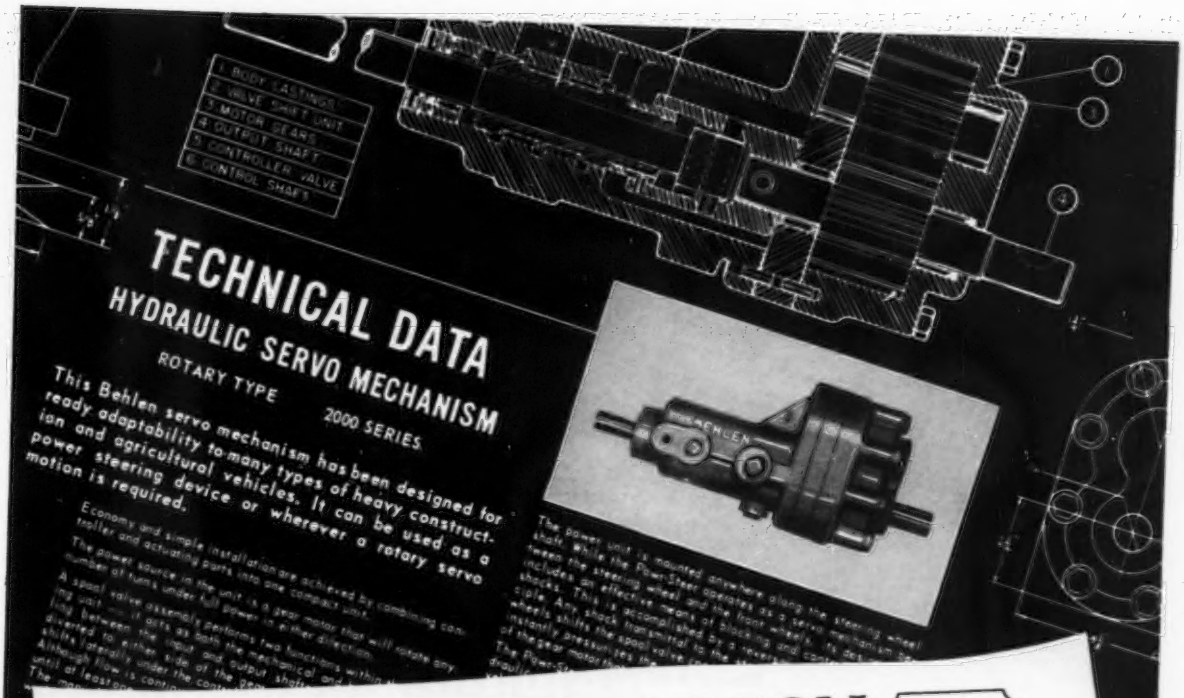
The opening paper on the morning program was presented by J. Porterfield and was on research developments with the plateau profile planter. This paper was followed by one on connecting links between agricultural engineering research and accepted farm practices, by L. N. Sorenson. Subjects covering what's new in earth moving equipment, by Jim Hoover; concrete tilt-up for farm buildings, by James W. McTaggart; and recruitment for agricultural engineering, by E. W. Schroeder, were also presented.

The theme of the afternoon program was on research in light building construction. Papers covering this theme were discussed by Fred Beckett, on pole stability under overturning loads; Yack C. Moseley, on pole stability under gravity and uplift loads; George Mahoney, on lightweight trussed rafters; and G. L. Nelson, on glued laminated framing. A business meeting followed the program and the following officers were elected: James S. Matthews, chairman; Jay Porterfield, vice-chairman; and Dale Turnbull, secretary-treasurer.

C. V. Phagan was lauded for his outstanding contribution to the Oklahoma Section during the past three years. A field inspection trip to observe research facilities of the agricultural engineering dept. at the Oklahoma State University closed the meeting.

ASAE president, Earl Anderson was the banquet speaker at the Oklahoma A & M Student Branch meeting, December 5, 1957. *(Above)* Mr. Anderson is discussing the FEI report with the student committee and their advisor, James Garton. *(Left to right)* Harvey Hamilton, William Wood, Ronald Noyes, Edward Constien, Professor Garton, Robert Schweikhard and President Anderson.

(Right) President Anderson congratulates Barbara Boyd, student chapter queen while Wayne Clyma, honor winner in the 1957 National Student Paper Award contest, looks on.



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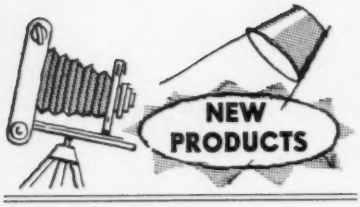
Dept. AE-2 Columbus, Nebraska

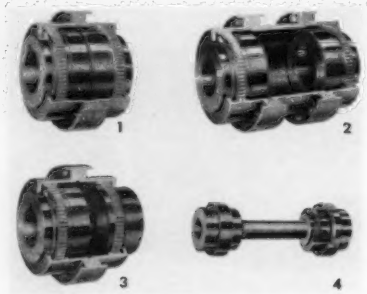
For more facts circle No. 87 on reply card



Geared Flexible Couplings

Link-Belt Co. has released a new book describing its line of improved geared flexible couplings.

Book 2775, a completely new 12-page publication, details pertinent application and



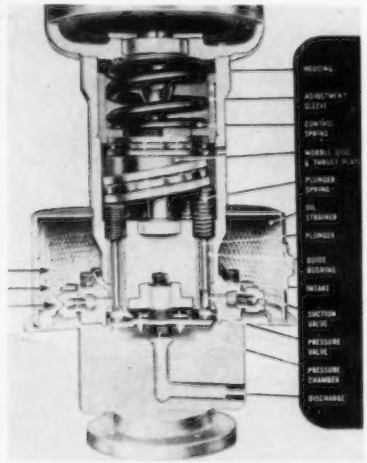
selection data for couplings with maximum bores ranging up to 7 in. and ratings from 2½ to 572-hp per 100 rpm.

The four types of geared flexible couplings, described in the new book are illustrated as: (1) SG, for direct-driven industrial equipment; (2) SGE, for connecting shafts that are separated by short distances; (3) SGM, for connecting tapered shafts; and (4) SGS, for shafts that are far apart.

(For more facts circle No. 1 on reply card)

New Hydraulic Pump

Equi-Flow Division, Vibro Mfg. Co., Inc., has introduced a new variable delivery high pressure axial multiplunger hydraulic pump.



The pump is said to develop 5700 psi. The oil delivery can be manually adjusted to any desired value (within available range) or can be left to vary automatically inversely with pressure-changes. Sizes from 1½ to 30 hp are offered either as bare pumps or as package power units.

(For more facts circle No. 2 on reply card)

Introduces 1960 Line

J. I. Case Co. has unveiled eight wheel-type and four crawler units to make up a 12 tractor line to be called their "1960 Line." The new tractor family combines new engineering developments with a new look in tractor styling.

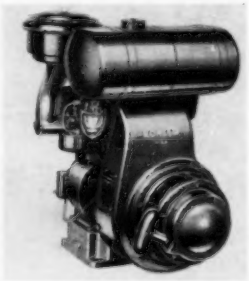
Featured is a new Case-O-Matic drive which enables the farmer to select the

proper gear, and then complete his job without shifting, stalling or using a clutch. The new drive links engine with transmission hydraulically to offer variable speed in every gear range with constant power to match each particular job, it is said.

(For more facts circle No. 3 on reply card)

New 6.6-HP Engine

Kohler Co. has announced new model K160T, a 6.6-hp, 4-cycle, short-stroke air-cooled engine with a retractable starter. Starting is provided by a self-contained

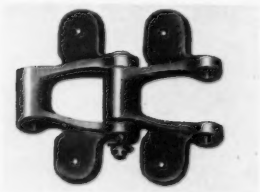


starting unit attached to the engine. The head is aluminum alloy with deep fins spaced for efficient cooling. The engine weighs 75 lb.

(For more facts circle No. 4 on reply card)

Conveyor Chain

Robert A. Main & Sons, Inc. has announced production of forged steel conveyor chain, each link made with a wing



attachment. This pin-type chain is made of forged quality steel and is heat treated. It can be furnished for acid or heat conditions using corrosion or heat resistant materials. The new chain is said to be easy to take apart or assemble. Each pin is locked against rotation. Each link has a wing attachment for attaching to wood or metal conveyor slats.

(For more facts circle No. 5 on reply card)

New Nozzle for Broadcast Spraying

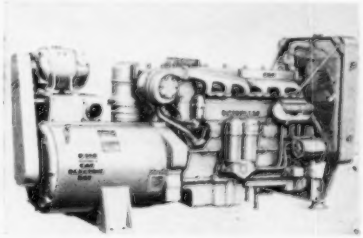
Spraying Systems Co. has announced a new spray nozzle tip for use with their GunJet No. 2 or No. 42 spray guns and de-

signed to project a spray in a flat spray pattern up to 42 ft wide. In use, the spray gun is mounted rigidly on the rear of the tractor about 3 ft above ground level and pointing to the rear. The new nozzle tip is made with four orifices to provide equalized distribution of the spray throughout the pattern area.

(For more facts circle No. 6 on reply card)

New Electric Sets

Caterpillar Tractor Co. has announced availability of its D318 (Series G) engine



as power unit for both turbocharged and naturally aspirated electric sets.

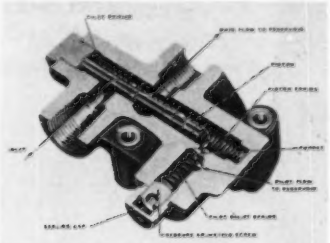
The new sets combine the recently-announced Series G equivalent of the D318 engine, with the space-saving and self-regulated constant voltage generator, to produce a compact unit for generation. The turbo-charged electric set arrangement is rated at 75 kw, and the naturally aspirated at 60 kw.

On both set versions, the generator produces 60-cycle, three-phase current at an option of 120, 240, 120/208 or 480 volts at 1800 rpm.

(For more facts circle No. 7 on reply card)

Hydraulic Relief Valve

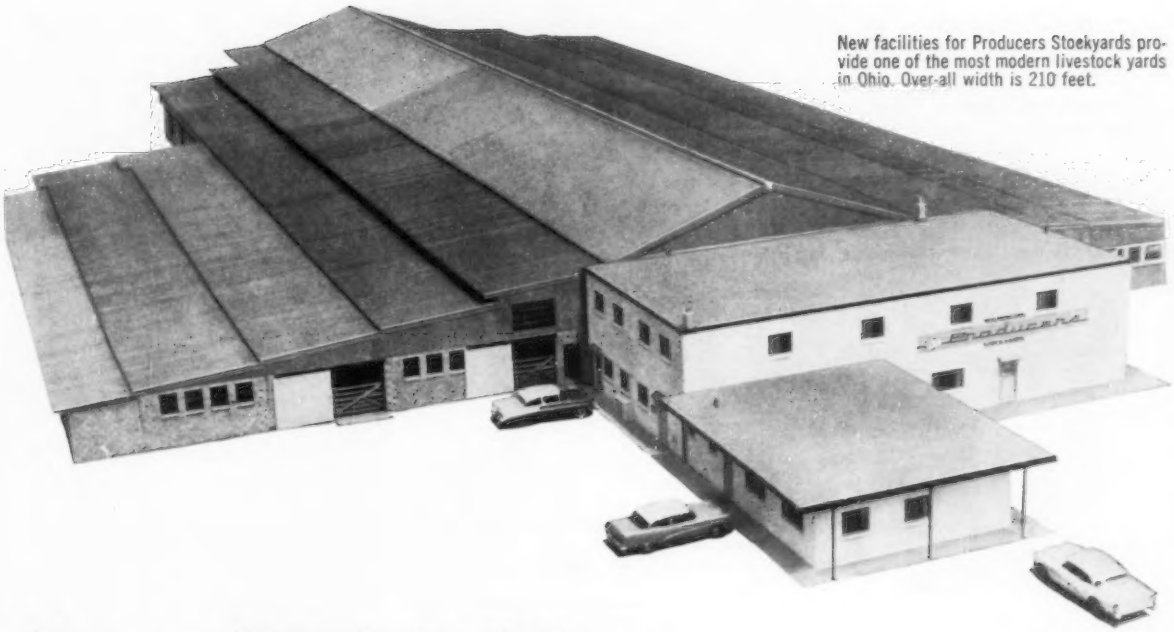
Webster Electric Co. has introduced a new pilot operated relief valve for hydraulic lifts. The new valve is adjustable from 500



to 2000 psi and has a maximum capacity of 20 gpm. Overall length of 4 15/16 in. permits mounting in limited space.

(For more facts circle No. 8 on reply card)

(Continued on page 112)



New facilities for Producers Stockyards provide one of the most modern livestock yards in Ohio. Over-all width is 210 feet.

Armco Steel Buildings

Put Stockyard Back in Business Quickly—At Low Cost

When fire destroyed their frame stockyards at Wilmington, Ohio, owners of Producers Livestock Association listed these top priority requirements for a replacement-structure:

Fast erection, low cost and noncombustibility.

To meet these specifications they decided to rebuild with Armco Steel Buildings. Less than six months after the fire, they were back in operation. A 60′ x 300′ Armco Building plus a series of Armco lean-to units now cover more than an acre of floor space.

In addition to cutting weeks, possibly months from construction time, Armco Buildings provided savings in erection costs for Producers Stockyards. Equally important, steel buildings reduce the threat of fire, keep insurance rates down.

Write us today for complete information about Armco Steel Buildings to meet your needs. Armco Drainage & Metal Products, Inc., 3823 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario. Export: The Armco International Corporation.

Spacious interior of 60′-wide main building assures livestock comfort.

ARMCO STEEL BUILDINGS

For more facts circle No. 88 on reply card

. . . New Products

(Continued from page 110)

New Seal for Tapered Roller Bearings

The Timken Roller Bearing Co. has developed a new approach in the sealing of tapered roller bearings. Called the Duoface seal, it combines the features of the outside diameter seal and the face type seal. One lip operates in the bearing housing

bore providing an outside diameter seal. The other lip operates against the smooth, flat, hardened and ground face of the bearing cup providing face type sealing.

The synthetic seal is supplied pressed onto the bearing cone thereby eliminating handling and assembly problems. No special tools and assembly fixtures are needed where close clearances exist with other machine parts. Since the seal adds very little width to the bearing, shorter hub and housing construction is possible. Seals are currently available on seven different sizes of bearings. These are by bore sizes: 0.750, 0.8437, 1.000, 1.250, 1.375, 1.500 and 2.6875 in.

(For more facts circle No. 10 on reply card)

New Plastic Pipe Line

Acme Rubber Mfg. Co. Div., Acme-Hamilton Mfg. Corp. has introduced a new

line of flexible, lightweight, non-corrosive plastic pipe and fittings.

The new pipe is made from virgin polyethelen, compounded with non-toxic ingredients. The pipe is said to resist acids, alkalies, metallic salts, most chemicals and the growth of mold and bacteria, and possesses immunity to rot, rust and electrolytic corrosion.

Insert-type fittings and clamps simplify piping installations, particularly where long lengths are required, and difficult bends are encountered. Piping is available in a wide range of nominal pipe sizes — ½, ¾, 1, 1¼, 1½, 2 and 3 in. — for pressure ratings from 55 to 100 psi.

(For more facts circle No. 14 on reply card)

New Traction-Type Dynamometers

W. C. Dillon & Co., Inc. has developed two new traction-type dynamometers. The new instruments have capacity ratings of 0-5,000 lb and 0-10,000 lb, and are de-

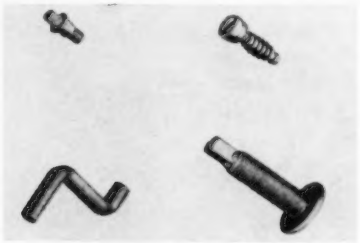
signed for the precision measurement of torque, weight, tension, traction or compression. Said to be unaffected by extremes in temperature, each unit reportedly can sustain accidental overload of up to 25 percent without injury to the calibration.

Both models are available calibrated in either pounds or kilos at no additional charge, feature adjustable zero settings and shatter-resistant dials and are available with either 5 or 10-in. diam dials. Dynamometers furnished with 5-in. dials weigh 8½ lb net; 10-in. models weigh 13 lb net.

(For more facts circle No. 11 on reply card)

Cold Heading Process Reduces Small Parts Cost

Russell, Burdsall & Ward Bolt and Nut Co. has announced that by using cold heading instead of machining, forging or other metalworking techniques, manufacturers are cutting the cost of producing small and medium size (maximum length about 6 in.) component parts. The process, developed by the fastener industry for the economic production of billions of bolts and screws, is also gaining favor because it produces a component said to be stronger than the metal from which it is made. Cold heading reportedly flows and compresses steel fibers to provide greater strength. With uninterrupted or uncut flow lines, the piece is said to be better able to withstand stress variations.



Value analysis of product components may show that cold heading can eliminate extra operations, allow use of fewer parts, make the component faster, or cut scrap losses in production. Shown are examples of savings and improved strength in component parts manufactured by the cold heading process.

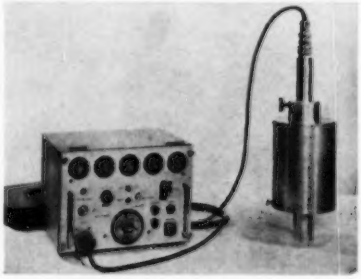
The insert screw (top, left) which is imbedded in a die cast plastic part, was formerly cut in a screw machine. Now made in a bolt making machine, savings in material and the faster speed of cold heading reduces cost. A two-piece assembly is replaced by one-piece cold headed part (top, right) by making hose clamp adjusting screw in one piece in a cold heading machine. The rod from which the shifter interlock lever (bottom, left) is made is bent into a double-L with two right angles in one operation in a bolt heading machine. The part was formerly made in a two-stage forging operation. A two-piece leveling screw (bottom, right) is made in one piece by cold heading process.

(For more facts circle No. 12 on reply card)

Soil Moisture and Density Tester

Nuclear-Chicago Corp. has announced a new radioactivity instrument designed for two-minute testing of soil moisture and density.

Operational principle of the d/M-Gauge is based on the varying degree that radioactivity is "scattered" when placed in contact with masses of different moisture content or density. This principle is applied by

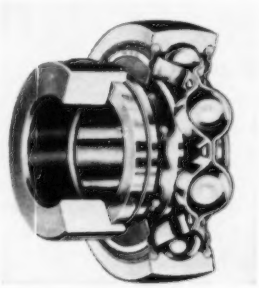


inserting a probe which contains a radioactive source into a soil media and then measuring the amount of scatter produced with a radioactivity counting device. An operator obtains a total "scatter count" from the scaler and locates a corresponding figure on a calibration chart. Moisture content or density of the soil being tested is read directly from the chart itself.

(For more facts circle No. 13 on reply card)

Prelubricated Bearings

Marlin-Rockwell Corp. announces a new series of power transmission ball bearings, designated as the RA series. These bearings are said to be especially adapted for installa-



tions requiring mounting of prelubricated bearings which require low maintenance and high protection against entrance of dirt and moisture.

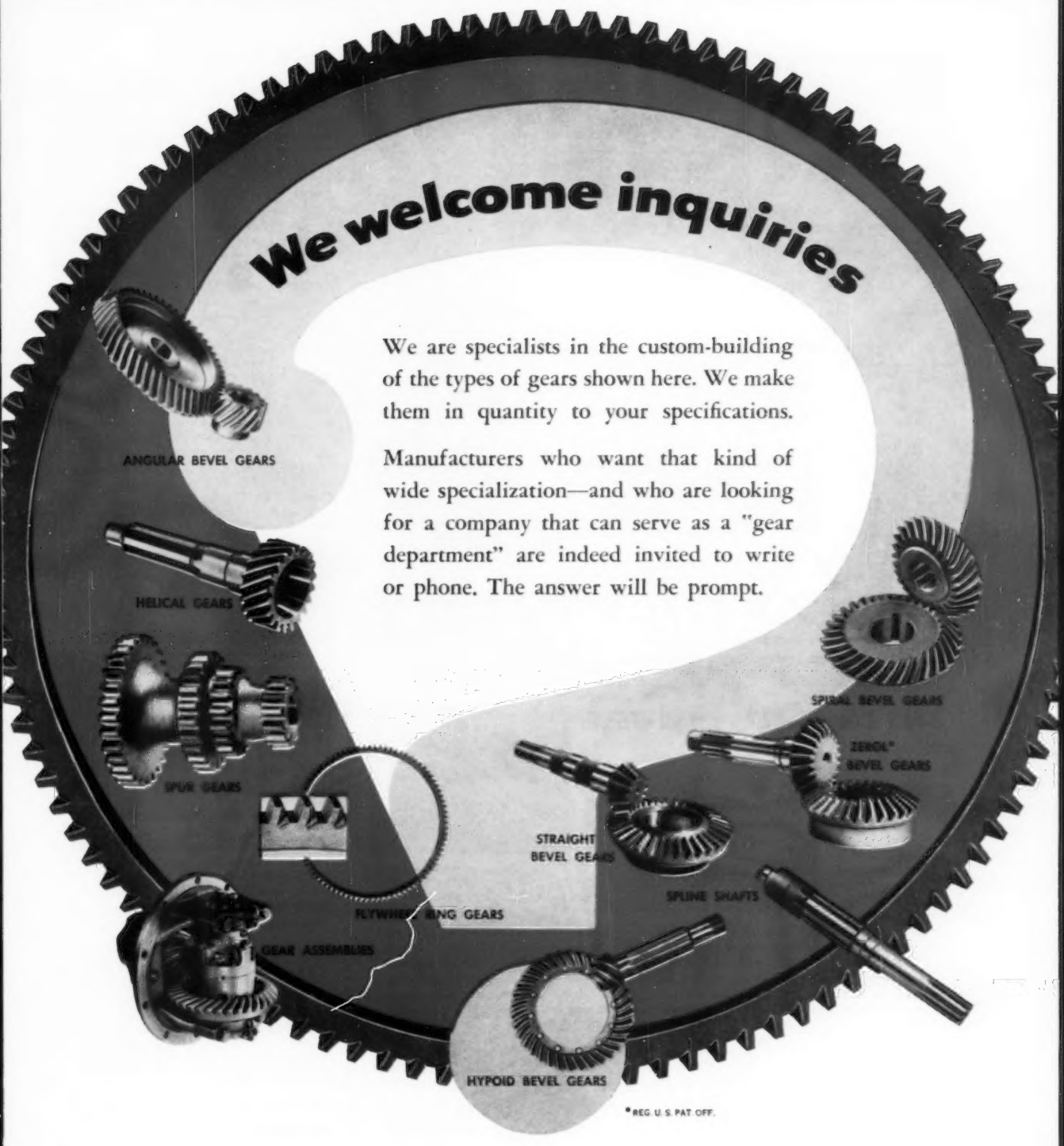
Designed for ease of installation, these bearings fit standard pressed steel flangette housings, and the bores will fit commercially ground inch shafting. A standard eccentric collar is used to lock the bearing to the shaft, eliminating the need for press fits, lock nuts, or other locking devices. The bearings are made with either a cylindrical or spherical profile of outer ring.

(For more facts circle No. 9 on reply card)

We welcome inquiries

We are specialists in the custom-building of the types of gears shown here. We make them in quantity to your specifications.

Manufacturers who want that kind of wide specialization—and who are looking for a company that can serve as a "gear department" are indeed invited to write or phone. The answer will be prompt.



*REG. U. S. PAT. OFF.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

For more facts circle No. 89 on reply card

MANUFACTURERS' LITERATURE

Power Unit

Allis-Chalmers Mfg. Co. — An 8-page two-color catalog (MS-1247) describing the B-125 power unit. Various components of the unit are illustrated. Specifications and a list of equipment available are included.

(For more facts circle No. 15 on reply card)

Rotary Gland Bearing Pump

Blackmer Pump Co. —An 8-page bulletin, No. 150, describing the company's rotary gland bearing pumps. It includes a pump selection and application chart, and a performance data table.

(For more facts circle No. 16 on reply card)

Silent Chain Drives

Link-Belt Co. — Book 2425 contains 88-pages of detailed engineering data and illustrations of silent chain's versatility in a wide range of applications. It includes tables of service factors, ratings, chain length and center distance computations; pre-engineered stock drives; a section outlining the procedure for selection of engineered drives, etc.

(For more facts circle No. 17 on reply card)

Ductile Iron Digest

International Nickel Co., Inc.—An 18-page illustrated booklet describing a new metal reportedly as strong as carbon steel which can be twisted and bent without cracking. It contains 24 case records showing how strength and toughness can be cast in tiny levers and huge engine frames.

(For more facts circle No. 18 on reply card)

Portable Heat

The Little Red Hen Equipment Co. — A 4-page booklet which describes the use and importance of portable auxiliary heat in agriculture. Illustration and description of the heaters are provided, including the construction, economy, and safety features.

(For more facts circle No. 19 on reply card)

Angle Iron Shear

Whitney Metal Tool Co. — A bulletin containing information on Whitney-Jensen No. 4 angle iron shear capable of cutting 2 x 2 x ¼-in. stock. It also describes a bender and a notcher. The bulletin gives dimensions and capacities including prices.

(For more facts circle No. 20 on reply card)

V-Belts

Goodyear Tire and Rubber Co. — A 16-page booklet, S-51107, on the testing, inspection and control of the quality of V-belts. It describes and illustrates how raw materials and finished belts are tested and inspected. One section explains quality control procedures, and another is concerned with experimental production.

(For more facts circle No. 21 on reply card)

Plastic Pipe Clamp

Wittek Mfg. Co. — A catalog sheet, form No. PP-1057, describing two types of stainless steel clamps for plastic pipe. A description of a special feature of both, the welding method of assembling the heads to the band, is included.

(For more facts circle No. 22 on reply card)

Testing and Calibration Instruments

Custom Scientific Instruments, Inc.—Catalog No. 58 contains illustrations and brief descriptions of 50 different units. These units include testing and calibration instruments and fixtures that appear in ASTM designation, federal, military and other specifications. The instruments for testing are in the fields of textile, plastic, rubber, paper, cement and insulation.

(For more facts circle No. 23 on reply card)

Hard-Facing Farm Implements

Wall Colmonoy Corp. — A 5-page illustrated engineering data sheet (No. 32) describing instructions and procedures for hard-facing farm implements such as plowshares, moldboards, landside plates, lister shares, etc.

(For more facts circle No. 24 on reply card)

New Home Booklet

West Coast Lumbermen's Association—An 8-page color booklet on how you can own a new home. It explains how to plan for better living in the near future, how to set up a definite new home program and how to select a home that fits the needs of the present and also the future. Charts are included which portray the advantages of buying over renting.

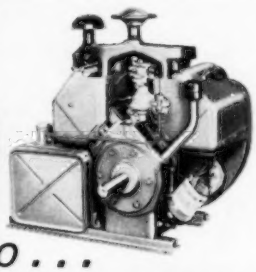
(For more facts circle No. 25 on reply card)

The Road Ahead

Caterpillar Tractor Co.—Form No. 32452 is a booklet designed to give the public a working knowledge of the future of American highways under the new highway building program authorized by Congress. Figures explain how much money each state will receive and for what the money will be used. Illustrations show how the new roads will look when they are finished. The bulletin explains the citizen's role in creating this network of modern highways and tells what steps are necessary to get the program under way in his area.

(For more facts circle No. 26 on reply card)

• Wisconsin-powered self-propelled Hagie Cotton Defoliator

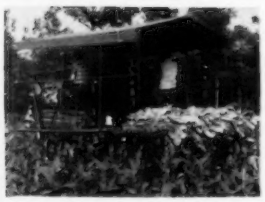


TODAY the swing is to . . .

WISCONSIN-POWERED

SELF-PROPELLED

farm equipment



• Wisconsin-powered self-propelled McCormick Swather

• Wisconsin-powered self-propelled Harrington Tobacco Harvester

• The growing popularity of Wisconsin-powered self-propelled equipment speaks for itself when you consider the advantages of Wisconsin Air-Cooling, Heavy-Duty Design and Construction and High Torque Performance.

AIR COOLING, as supplied on all Wisconsin Engines (3 to 56 hp.) permits extremely compact installation, keeps engine weight to a minimum and requires the least amount of attention. You get a highly maneuverable, versatile machine with full control at your finger tips, under all field conditions . . . uphill, downhill, over rough or soft ground, working in heavily cropped fields, getting in and out of tight corners and keeping your eye on the work that is being done. And you get efficient cooling at all temperatures up to 140° F. No water to boil away in hot weather; no freeze-ups in cold weather.

HEAVY-DUTY DESIGN AND CONSTRUCTION provides the in-built stamina that can "take it" no matter how rough or tough the going. The drop-forged crankshaft runs on tapered roller bearings at BOTH ends.

BASIC HIGH TORQUE supplies the load-holding Lugging Power that *hangs on* through the shock loads and heavy pulls — helps to prevent stalling.

More than 2,000 Authorized Service Stations (there is one near you) carry replacement parts.

These are some of the reasons why leading builders of self-propelled farm equipment and a great variety of other farm and orchard equipment specify "Wisconsin Power." It will pay you to do the same for your equipment. Write for free copy of Engine Bulletin S-223.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

For more facts circle No. 95 on reply card

The good name of your machine is LINK-BELT's first consideration . . . TRADE MARK . . . and quality should be your first consideration in the chain you buy

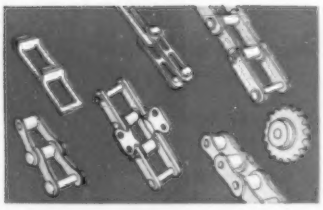
JOHN DEERE No. 30 two-row, double level-bed potato digger uses Link-Belt SS steel roller chain for dependable power transmission.

Is the chain you use as good as the machine you make?

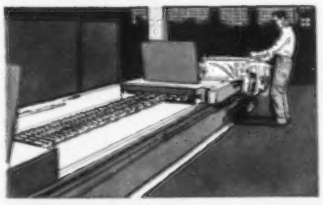
Here's how LINK-BELT matches drive and conveying chain to the field requirements of your equipment

THE Link-Belt double-arrow trademark on chain means that each link in every length conforms to rigid quality and uniformity specifications. And it's your assurance that the drive or conveyor chain specified will maintain rated performance and efficiency on your machine.

From the world's largest chain plant, Link-Belt offers you the economies of mass-production . . . represents a ready source for all your chain and sprocket needs. For prompt service, call your nearby Link-Belt office. 14,745



COMPLETE LINE of agricultural chains, sprocket wheels and attachments permits cost-saving specialization — offers right chain for all conveyor and drive needs.



ACCURATE MANUFACTURE AND CONTINUOUS INSPECTION with modern, specialized machines allow economies of large-scale production. Extensive facilities provide ample capacity to meet your production schedules.

LABORATORY CONTROL assures you that each chain meets rigid uniformity specifications. Our modern laboratory continuously explores new refinements to increase chain life.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

For more facts circle No. 90 on reply card

No. 25 Actual Size
Pitch 1/4" Width 1/8"

No. 35 Actual Size
Pitch 3/8" Width 3/16"

No. 41 Actual Size
Pitch 1/2" Width 1/4"

No. 40 Actual Size
Pitch 1/2" Width 5/16"

USE ACME CHAIN FOR EVERY POWER TRANSMISSION REQUIREMENT:

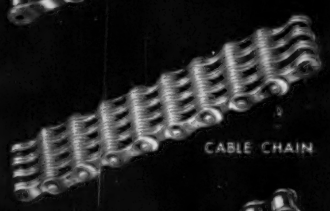
driving·conveying·timing

Acme Chains are efficient, economical and positive for power transmission. They are readily adaptable to any drive when maximum efficiency is essential. Correct principles of design provide operating characteristics superior to any other method of power transmission. Replacement parts always readily available from stock.

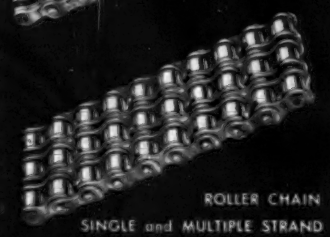
Your inquiry will place a skilled Acme engineer at work on your power transmission problems.

No. 50 Actual Size Pitch 5/8" Width 3/8"

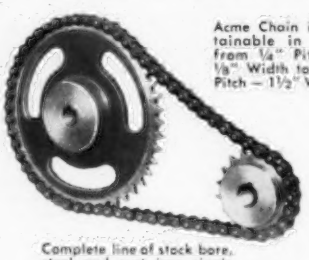
CONVEYOR CHAIN
STANDARD and
OVERSIZE
ROLLERS



CABLE CHAIN



ROLLER CHAIN
SINGLE and MULTIPLE STRAND



Acme Chain is obtainable in sizes from ¼" Pitch — ⅛" Width to 2½" Pitch — 1½" Width.

Complete line of stock bore, steel and cast iron single sprockets, cast iron hub sprockets and all steel split or solid hub sprockets available.

FREE CATALOG

Write Dept. 9-K for your 80 page copy of Acme's latest catalog. Packed with valuable data.

Call **ACME** for Service

Acme Chain Corporation

HOLYOKE
MASSACHUSETTS

The following bulletins have been released recently. Copies may be obtained by writing to author or institution listed with each.

Preliminary Studies of Mechanical Dewatering as an Aid to Dehydration of Florida Forages, by J. W. Randolph, D. B. Vincent and R. V. Allison. Reprinted from "The Soil and Crop Science Society of Florida," Proceedings, Vol. 16, 1956. For further information write to J. W. Randolph, Everglades Experiment Station, Belle Glade, Fla.

Career Satisfactions of Professional Engineers in Industry, a research survey developed for the Professional Engineers Conference Board for Industry in cooperation with the National Society of Professional Engineers. Prices, $1.50 per copy to NSPE members and $3.00 per copy to non-members. Professional Engineers Conference Board for Industry, 2029 K St., N.W., Washington 6, D. C.

Cut the Machinery Costs that Cut Your Profits, by R. O. Gilden and J. B. Claar. Federal Extension Service, U. S. Department of Agriculture, Washington, D. C.

Arizona Loses a Water Supply, by G. E. P. Smith, Arizona Agricultural Experiment Station, Tucson, Ariz. Price $1.00.

The Practice of Consulting Engineering, report No. 106, prepared by the Task Committee on Consulting Practice and approved by the Board of Directors of Engineers Joint Council. Engineers Joint Council, 29 W. 39th St., New York 18, N. Y. Price $1.50.

The Testing World, Vol. 1, No. 1, December, 1957. Published by Soiltest Inc., 4711 W. North Ave., Chicago 39, Ill.

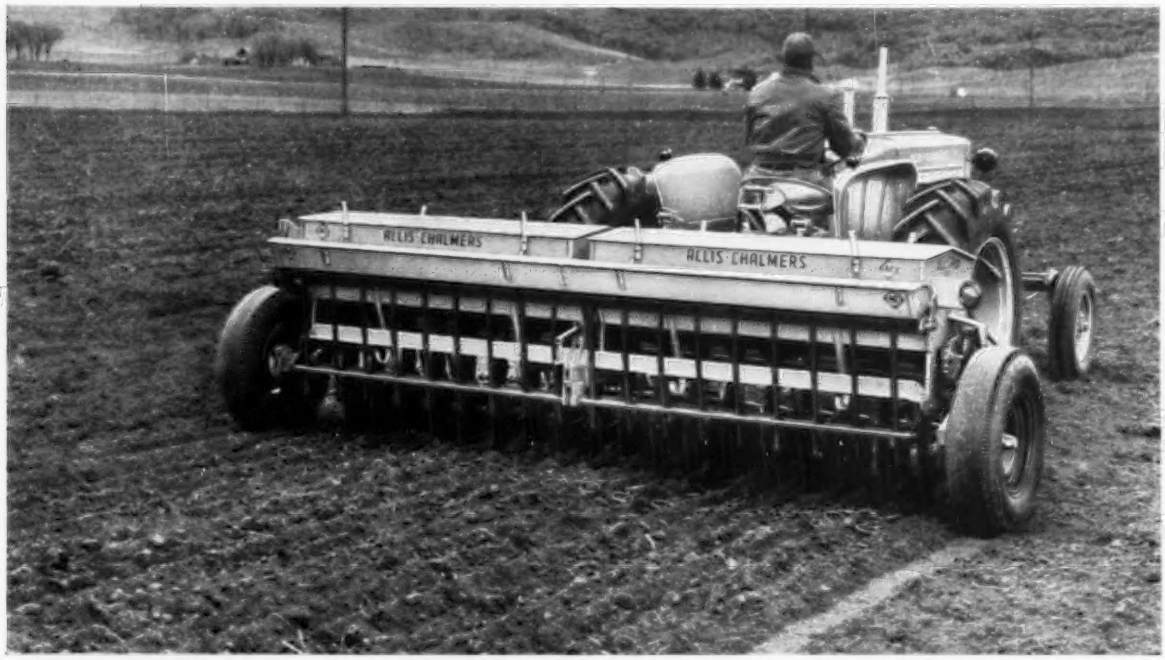
Electric House Heating, by J. P. Schaenzer. REA Bulletin 142-1, December, 1957. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

Tillage Practices in Relation to Crop Yields, Power Requirements and Soil Properties, by G. L. Byers and L. R. Webber. Reprinted from Canadian Journal of Soil Science 37:71-78, August, 1957. For further information write to L. R. Webber, Department of Soils, Ontario Agricultural College, Guelph, Ont., Canada.

1956 Thirty-Second Annual Report of the Kansas Committee on the Relation of Electricity to Agriculture. Agricultural Engineering Dept., Kansas State College, Manhattan, Kans.

Rainfall Relations on Small Areas in Illinois, by F. A. Huff and J. C. Neill. Bulletin No. 44. Illinois State Water Survey, Dept. of Registration and Education, Urbana, Ill.

Types and Uses of Infrared Heat Lamps on the Farm, and *New Farm Work for Electricity*, by D. W. Works and J. W. Martin. *Operating and Maintaining Your Sprinkler System*, by D. C. Larsen, D. W. Works and G. M. McMaster. Farm Electrification Leaflets Nos. 35, 36 and 37, respectively. University of Idaho, College of Agriculture, Moscow, Ida.



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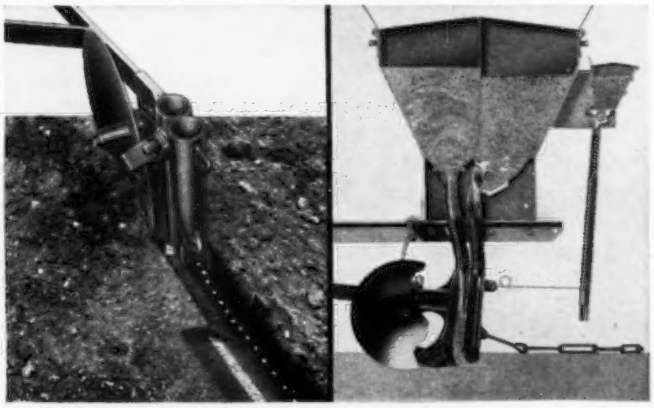

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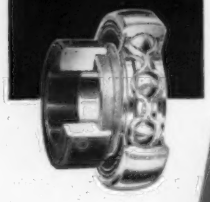

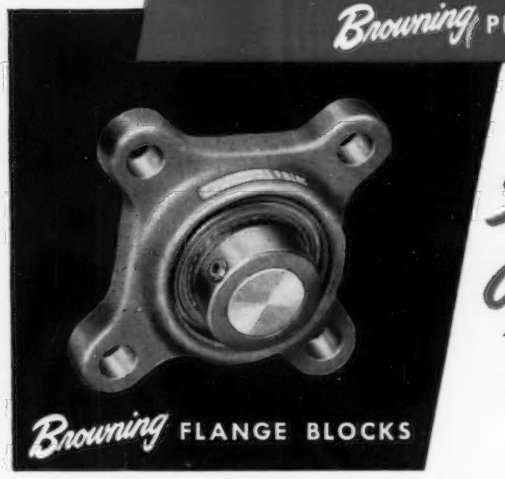

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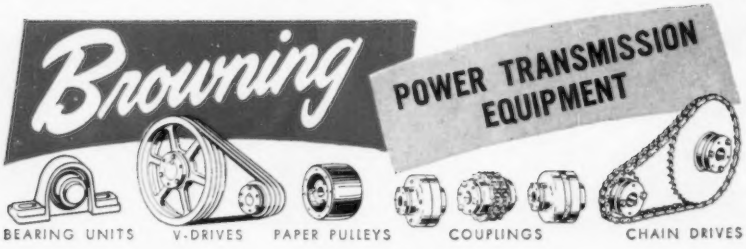

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Aghabi, Fuad — Proj. engr., Baker-Herza Co., P.O. Box 328, Amman, Jordan, Arabia

Allen, David I. — Agr. engr., Dept. of Agriculture, Georgetown, British Guiana, South America

Ames, William S. — District mgr., Fafnir Bearing Co., 1607 Hennepin Ave., Minneapolis 3, Minn.

Arms, John C. — Jr. engr., J. I. Case Co. (Mail) 1000 17th Ave., Rock Island, Ill.

Barraclough, Jack T.—Hydraulic engr., U.S. Geological Survey, Water Resources Div., Ground Water Branch. (Mail) P.O. Box 1073, Tallahassee, Fla.

Bistline, Stanley D. — Jr. test engr., Letourneau-Westinghouse Co. (Mail) 830 Bartlett Ct., Peoria, Ill.

Buchholz, J. Leonard — Asst. mechanical engr., International Harvester Co., 505-41st St., Rock Island, Ill.

Camp, Joe B. — Eng. spec., SCS, USDA. (Mail) 4015 Alberta, Pecos, Texas

Cluff, John C. — Agr. engr., SCS, USDA (Mail) P.O. Box 1502, Muskogee, Okla.

Dreidger, Richard L.—Hydraulic engr., H. G. Acres Ltd., consulting engineers. (Mail) 14030 Douglas Rd., North Surrey, B. C.

Durham, O. H. — District engr., Marlow Pumps, Div. of Bell & Gassett Co. (Mail) 2414 Lakeland, El Dorado, Ark.

Fry, Arthur W. — Jr. engr., irrigation dept., University of Calif., Davis, Calif.

Goode, Cecil C. Jr.—Agr. engr., Warren Rural Electric Co-op. Corp., Leitchfield, Ky.

Harris, Kenneth J.—Proj. engr., John Deere Research and Engineering Center. (Mail) 114 Wellington, Waterloo, Iowa

Hodges, Harley R. — Area engr., SCS, USDA. (Mail) 3207 S. Deering Rd., R.R. 5, Jackson, Mich.

Ireland, Wilton C. — Vice-pres. and gen. mgr., Central Tractor Co. (Mail) 1314 N.E. 7th Terrace, Gainesville, Fla.

Kordik, Kenneth S. — Prod. engr., Le Tourneau Westinghouse Co. (Mail) R.R. 1, P.O. Box 83, Chillicothe, Ill.

McDaniel, Donald M. — Agr. engr., SCS, USDA. (Mail) 643 Mission Dr., Camarillo, Calif.

Melcher, M. A. — Des. engr., Kosch Mfg. Co., Columbus, Nebr.

(Continued on page 125)

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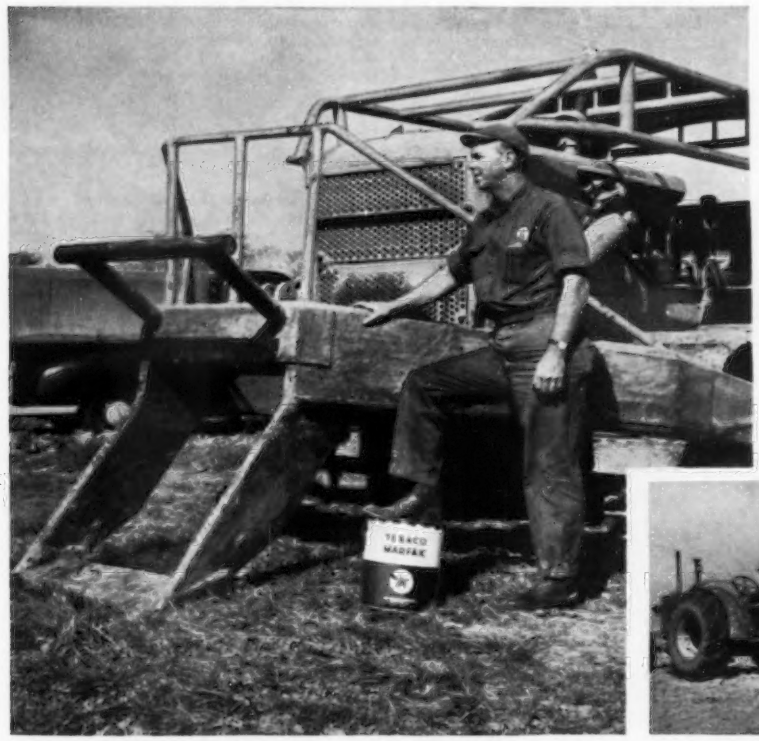

THE homemade stump puller and a dump wagon shown save costly time and labor in clearing land on the Norris Raun farm near El Campo, Texas. Both are activated by hydraulic power.

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This novel two-wheel dump wagon is operated by hydraulic power. Picture shows driver unloading stumps by tilting wagon box. The stump puller and dump wagon save time and labor in clearing land on the Norris Raun farm near El Campo, Texas.

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Farm Water Management for Erosion Control, by R. P. Beasley and J. C. Wooley. Published by Lucas Brothers, Columbia, Mo. $4.75.

This text gives a brief history of erosion and discusses its effect on our present day economy. It explains how erosion occurs, evaluates the various factors affecting it and discusses methods of control. There is a chapter on farm planning in which the necessity of planning the farm as an efficient production unit as well as for control of erosion is emphasized. Also a section which deals with a new method for laying out and constructing terraces by which it is possible to reduce the area in point rows and the sharpness of curves in a terrace system is included.

The book is divided into two parts. The material presented in the chapters is designed for classroom discussion and that in the exercises for laboratory or field work.

Drying Farm Crops, by Carl W. Hall. Cloth, 5½ x 8½ inches, 336 pages, illustrated and indexed. Published by Agricultural Consulting Associates, Inc., Reynoldsburg, Ohio. Order from Edwards Brothers, Inc., Ann Arbor, Mich. $7.00.

This is said to be the first book devoted entirely to drying farm crops and related topics. Basic data on equilibrium moisture content, drying theory, moisture determination, use of heated air, forced air drying systems, air movement including fans and ducts, and aeration systems are presented. Problems are included at the end of each chapter making the book useful as a text.

Drying of cereal crops and forages are covered with reference to other crops. Typical drying and aeration installations are presented including costs involved and returns which can be expected. References, figures and tables are included. Both practical and technical phases are presented making the book particularly useful to those interested in the engineering and application phases of drying.

Regime Behaviour of Canals and Rivers, by T. Blench. Cloth, 8¾ x 5½ inches, 150 pages, illustrated and indexed. Published by Butterworth & Co. (Canada) Ltd., 1367 Danforth Ave., Toronto 6, Ont. $6.00.

The aim of this book is to give the practicing engineer the means to solve, with practical quantitative accuracy, problems that arise in dealing with canals and rivers that form their boundaries from sediment. A special chapter discusses fundamental dynamics, and an appendix gives data and the location of all formulas.

The contents include chapters on the historical development of regime theory of canals; application of regime formulas to canals of small bed-load charge; application of regime formulas to canals of large bed-load charge; dynamical aspects of regime forms; problems related to meandering; problems related to breadth, depth, and slope; river models; appendices; and a glossary of standard terms.

ASTM Viscosity Tables for Kinematic Viscosity Conversions and Viscosity Index Calculations, ASTM special technical publication No. 43-B. Paper cover, 6 x 9 inches and 65 pages. Copies of this book may be obtained from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $2.00.

Tables in this book provide a means for viscosity conversions and for obtaining basic values for calculation of viscosity index. The tables were prepared for use by petroleum chemists, lubrication engineers, and production personnel, and include: conversion of kinematic viscosity to saybolt universal viscosity, conversion of kinematic viscosity to saybolt furol viscosity, basic values for calculating viscosity index from kinematic viscosity; values for calculating viscosity index from saybolt universal viscosity; and factors for converting kinematic viscosity to saybolt universal viscosity at temperatures from −100 to +500 F.

Mathematics for Science and Engineering, by Philip L. Alger, based on "Engineering Mathematics," by Charles P. Steinmetz. Cloth, 6 x 9 inches, xi + 360 pages, indexed and illustrated. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y. $5.50.

The purpose of the book is to help the student or engineer to use mathematics effectively by showing the unity and simplicity of the basic mathematical ideas on the one hand, and by making numerical calculations easy on the other. Arithmetic, trigonometry, algebra, calculus, probability, etc., are considered in successive chapters.

The book is reported to contain about 80 percent of the mathematical procedures and methods which an engineer or technician will need to use in the course of his career. Special emphasis is given to complex numbers, infinite series, and methods of approximation.

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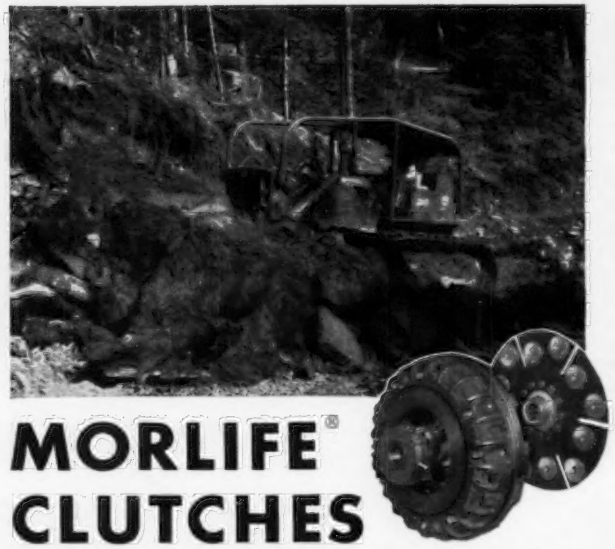

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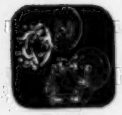
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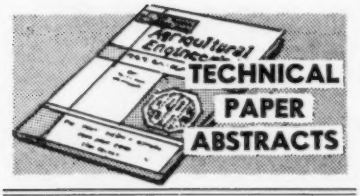


Following are brief reviews of papers presented at ASAE meetings or other agricultural engineering papers of which complete copies are available. Information concerning copies of these papers may be obtained by writing to the American Society of Agricultural Engineers, St. Joseph, Mich.

Economic Comparisons of Low and High Pressure Sprinkler Systems, by Ray E. Foss, regional sales manager, W. R. Ames, Co., Indianapolis, Ind. Paper presented at the Golden Anniversary Meeting of ASAE in East Lansing, Mich., June, 1957, on a program arranged by the Soil and Water Division. Paper No. **57-93.**

This paper compares nine designs of sprinkler irrigation systems for a 160-acre corn field, using varying pressures from 37 psi to 95 psi at the sprinkler nozzles. It presents actual cost figures broken down into the factors of labor, power and fixed costs in order to arrive at a total seasonal cost for all nine designs. Two points that design engineers should keep in mind are stressed, namely, the necessity to know and study the "facts" and to be aware that his recommendations are to be pointed at helping each individual farmer increase his profits.

Preservative Treatment of Wood for Farm Use, by J. Oscar Blew, Jr., U.S. Forest Products Laboratory, Madison, Wis. Paper presented at the Winter Meeting of ASAE in Chicago, Ill., December, 1957, on a program arranged by the Farm Structures Division. Paper No. **57-569.**

In this paper it is emphasized that wood has always been a highly useful material on the farm, but that preservative treatment can increase its effectiveness when it is exposed to moist conditions. It is pointed out that the life of fence posts and poles for farm structures can be increased from five to ten times through effective wood preservation. The wide variety of wood preservatives and methods by which they may be applied to meet the various needs for wood preservation on the farm is stressed.

Functions and Values of Industrial Research, by C. E. Barthel, Jr., assistant director of Armour Research Foundation of Illinois Institute of Technology. Paper presented at the Winter Meeting of ASAE in Chicago, Ill., December, 1957, Paper No. **57-704.**

Industrial research has grown rapidly in the last two decades. According to this paper, however, the research accomplishments of the last half century will be eclipsed by the events of the next 20 years. An expanded research effort will be required to feed the rapidly growing population and maintain a standard of living equivalent to that of today, and to improve the standard of living will mean even greater effort.

Major actions which should be taken by the nation to help in the scientific and engineering progress are discussed. The responsibilities of the scientists and engineers who must carry a major burden in the integration of science and technology into the plans for the future are also included. It is pointed out that because of the wide-spread attention currently focused on science and technology as the result of scientific advances in Russia, the time is ripe for the scientists and engineers to take positive action in these areas.

Farm Fence Specifications, by J. S. Boyd, associate professor of agricultural engineering, Michigan State University. Paper presented at the Winter Meeting of ASAE in Chicago, Ill., December, 1957, on a program arranged by the Farm Structures Program. Paper No. **57-657.**

This paper is a report of the Farm Fence Construction Standards Committee on specifications for constructing farm fences. Both industry and public service agencies are represented on the committee which is attempting to put in writing the details necessary to good fence construction.

The need for this type of information became apparent when it came time to write specifications for right of way fences along various highway projects, since specific details were lacking. Temporary specifications were prepared from the limited information available, most of which is said to have developed from common usage. The specifications have been revised periodically as more information became available.

Mosquito Reduction by Good Agricultural Practices, by Sterling Davis, irrigation engineer, (SWCRD, ARS) USDA, Chinook, Mont. Paper presented at the Winter Meeting of ASAE, Chicago, Ill., December, 1957, on a program arranged by the Soil and Water Division. Paper No. **57-533.**

This paper presents results of cooperative studies conducted in the Milk River Valley of Montana on the effect of good agricultural practices on mosquito production. Many irrigated agricultural areas are plagued with mosquitoes. Studies in the Milk River Valley show that over 90 percent of the mosquitoes produced are associated with irrigation water.

Investigations are being conducted on the high percent clay content soils in an effort to determine the potential production under different moisture levels where fertilizer is applied on the present native grass. The ability of the soil to grow other more productive crops is also being determined. Results indicate better farm practices can increase production many times and not produce mosquitoes.

Irrigation practices have been evaluated on other soil types and water that is applied as recommended will not produce mosquitoes. Procedures for reducing the mosquito producing areas are also given in this paper.

A Low Cost Crop Moisture Tester, by B. Carl Haynes, ARS, University of Georgia, Athens. Paper presented at the Winter Meeting of ASAE in Chicago, Ill., December, 1957, on a program arranged by the Electric Power and Processing Division. Paper No. **57-593.**

This paper presents a brief discussion of several of the most commonly used, and widely accepted grain moisture meters.

Further discussion describes the adaptation of a commercially manufactured resistance-capacitance tester for determining grain moisture. The author points out the low cost and adaptability of such an R/C tester circuit in connection with measuring grain moisture.

Selecting the Water Year Applicable to Small Agricultural Watersheds, by D. L. Brakensiek, hydraulic engineer, ARS, Coshocton, Ohio. Paper presented at the Winter Meeting of ASAE in Chicago, Ill., on a program arranged by the Soil and Water Division (Hydrology Group). Paper No. **57-537.**

Estimation of water yield from agricultural areas requires the derivation of a relationship between annual runoff and other measurable factors. In the derivation of such relationships the analyst is faced with the question of what annual period should be used for defining annual runoff and annual precipitation.

This paper presents an objective procedure for defining an optimum water year. The procedure, which requires the calculation of simple correlation coefficients between annual runoff and annual precipitation for various annual periods, is reported to be simple to apply. Optimum water years were determined for several regions in the United States. It was found that the common practice of starting a water year on October 1 should be avoided when working with small agricultural areas.

Diversion Terraces for Erosion Control and Drainage, by Frank R. Brower, Jr., state conservation engineer, SCS, Harrisburg, Pa. Paper presented at the Winter Meeting of ASAE in Chicago, Ill., December, 1957, on a program arranged by the Soil and Water Division. Paper No. **57-550.**

This paper is a discussion of the present concept in the planning and installation of diversion terraces by the Soil Conservation Service in Pennsylvania. Included are recommended spacings for both erosion control and for drainage as well as an extract of the Diversion Terrace Construction Guide used to secure desired cross sectional dimensions. By the modernization of this conservation practice a water management system for agricultural lands on sloping hillsides is becoming a reality.

Tandem Tractor Studies, by J. A. Garman, research dept., Caterpillar Tractor Co., Peoria, Ill. Paper presented at the Winter Meeting of ASAE in Chicago, Ill., December, 1957, on a program arranged by the Power and Machinery Division. Paper No. **57-508.**

This paper describes briefly the tandem tractor research project conducted at Cornell University from July 1956 to August 1957. Economic factors affecting the development and use of tandem tractors are discussed. Total tillable acreage, wage rates, and crop rotations are related graphically to determine the size of farm required to justify a tandem tractor. An evaluation of construction and performance of the unit at Cornell is given. Static and dynamic tire loadings are examined. Recommendations for future designs are included in the conclusions.

Detailed information about this project is contained in a thesis, with the same title, available at the Cornell University Library, Ithaca, N. Y.

. . . Membership Applicants

(Continued from page 118)

Mennenga, Curtis L. — On duty with the U.S. Air Force (Mail) R.R. 1, Belmond, Iowa

Michael, Glen A.—On duty with the U.S. Air Force. (Mail) R.R. 1, Farmersville, Ohio

Mueller, Peter A. — Sales and engr., Brummer Seal Co., 1320 McKinley Ave., Chicago Heights, Ill.

Oliver, Robert P. — Sales mgr., Everpure, Inc., 2627 W. 19th St., Chicago 8, Ill.

Poucher, Gordon L. — Rural dev. rep., Florida Power Corp., P.O. Box 4042, St. Petersburg 1, Fla.

Raney, William A. — Acting head, irrigation and drainage section, Eastern Soil and Water Management Branch, ARS, USDA, Rm. 29, Plant Industry Sta., Beltsville, Md.

Rao, Bhavana N. — Res. scholar, agr. eng. dept., Indian Institute of Technology, Kharagpur, India

Schenk, George W. — Mgr. of Mich. sales, Aerovent Fan & Equipment, Inc. (Mail) 4200 Donald St., Lansing 10, Mich.

Sheridan, Vincent G. — Civil engr., Bureau of Claims, N.Y.C. Board of Water Supply. (Mail) R.R. 2, Catskill, N. Y.

Thompson, Roy D. Jr. — Agr. engr., SCS, USDA. (Mail) P.O. Box 966, Vernon, Texas

Walker, John J. — Work unit engr., SCS, USDA. (Mail) P.O. Box 562, Rupert, Idaho

Yadav, Kartar S. — Lecturer and teacher, agr. eng. dept., Indian Institute of Technology, Kharagpur, India

Transfer of Membership

Ball, Wilbur P. — c/o Chief of Stanford Staff, DESU Contract, USOM, APO 928, San Francisco, Calif. (Affiliate to Associate Member)

Chartier, Yves—Agr. engr., farm bldg. div., Dept. of Agriculture. (Mail) 151 rue des Franciscains, Quebec, P. Q., Canada (Affiliate to Associate Member)

Hurst, Homer T. — Assoc. prof., agr. eng. dept., Virginia Polytechnic Institute, Blacksburg, Va. (Associate Member to Member)

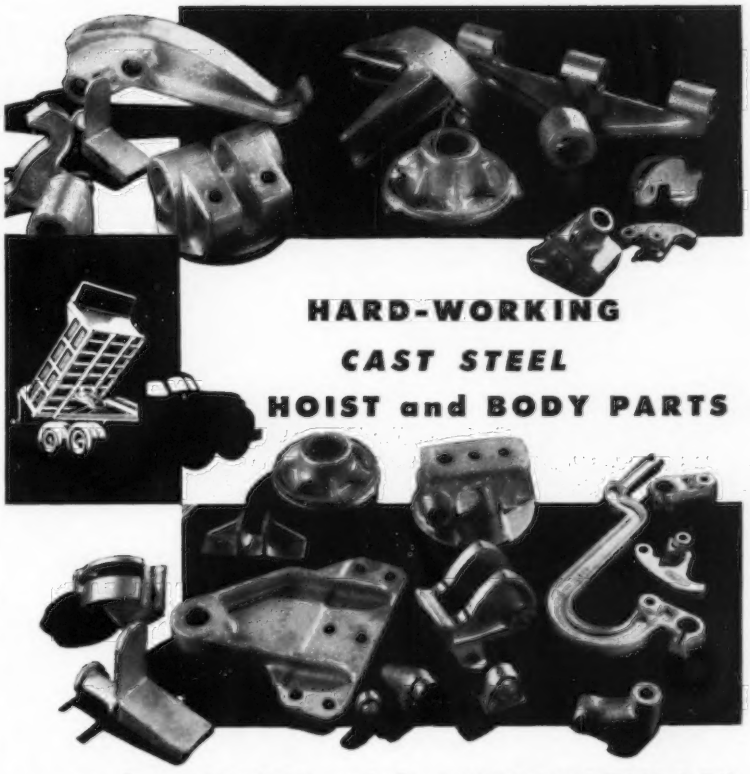
Ingram, Troy L. — Div. rural service engr., Alabama Power Co. (Mail) 6 Brookhaven, Tuscaloosa, Ala. (Associate Member to Member)

Korpela, Walter G. — Des. engr., International Harvester Co. (Mail) 712 - 4th Ave., Silvis, Ill. (Affiliate to Associate Member)

Moses, Jack G. — Area engr., SCS, USDA. (Mail) 1214 Oak St., Rocky Mount, Va. (Associate Member to Member)

Parson, Bernard L. — Assoc. prof., agr. eng. dept., Virginia Polytechnic Institute, Blacksburg, Va. (Associate Member to Member)

Steiger, Paul E. — Farm service rep., N. Y. State Electric & Gas Corp., Lancaster, N. Y. (Affiliate to Associate Member)



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PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated. "Agricultural Engineer" as used in these listings is not intended to imply any specific level of proficiency or registration as a professional engineer. Items published herein are summaries of mimeographed listings carried in the Personnel Service, copies of which will be furnished on request. To be listed in this Bulletin, request form for Personnel Service listings.

POSITIONS OPEN — 1957 — JUNE — O-170-730. AUGUST — O-183-734, 196-735, 248-736, 255-737, 259-738. SEPTEMBER — O-267-742, 267-743, 267- 744, 292-746, 284-747, 284-748. OCTOBER—O-272-749, 334-750, 334-751, 339-752, 339-753, 336-754, 314-755. NOVEMBER — O-350-756, 350-757, 360-758, 369-759, 362-760, 379-761, 380-762. DECEMBER — O-385-763, 386-764, 387-765, 412-766, 370-767. 1958 JANUARY—O-436-768, 478-769.

POSITIONS WANTED — 1957 — JUNE — W-186-11, 171-12, 180-13, 190-14, JULY—W-193-15, 192-16, 238-17. AUGUST—W-206-18, 254-22, 239-23, 256-25, 261-26. SEPTEMBER — W-278-27, 276-28, 262-29, 286-32, 299-33, 290-34. OCTOBER — W-326-36, 335-37, 331-38, 340-39, 341-40, 301-41, 297-42. NOVEMBER—W-337-43, 320-44, 344-45, 356-47, 357-48, 342-49, 291-50, 363-51. DECEMBER — W-371-52, 378-53, 394-54, 405-55, 409-56, 415-57. 1958—JANUARY—W-447-58, 410-59, 381-60, 466-61, 484-62, 485-63, 3-1, 4-2.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEERS for graduate research assistantships in farm structures, farm electrification, and farm power. Half time available for credit work in graduate program for MS degree. Midwestern land-grant university. BS degree in agricultural engineering or its engineering equivalent. Interest in research and desire to pursue graduate program for MS degree. Well prepared student can complete requirements for MS degree in one calendar year. Salary $2200-2400. Twelve-month appointment, eleven months duty, one month vacation. O-12-801

AGRICULTURAL ENGINEER for development and promotion of additional farm use of electric power, with electric cooperative in Mid-South. Age 25-35. Agricultural or electrical engineering degree. Sales, public relations, or agricultural engineering experience. Good health, attitude and personal habits. Should meet people easily and be able to make public appearances, like church and civic work. Must not use alcohol. Group insurance, retirement plan and social security. Salary open. O-17-802

AGRICULTURAL ENGINEERS (2), one in research and one in extension in the farm structures field. Particularly interested in candidates who have completed undergraduate work in agricultural engineering specializing in structures and wish to work for advanced degrees. Can arrange part or full time salary depending on amount of graduate work taken. Excellent salary scale and opportunities for advancement in large Midwestern university. Good fringe benefits, social security, state retirement system. Health and life insurance available at very low rates. Will also consider candidates who have completed graduate training and have some experience. O-48-803

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for design and development of agricultural machinery with manufacturer, anywhere in U.S.A. Married. Age 28. BSAE, 1951, Iowa State College. Farm background. Over 5 years experience in management training and design engineering with farm equipment manufacturer. Available on reasonable notice. Salary open. W-13-3

AGRICULTURAL ENGINEER for design, development or research with manufacturer of farm equipment, preferably in Midwest. Single. Age 23. No disability. BSAE, December, 1957, Michigan State University. Summer work in physical test laboratory. Salary $450-500 per month. W-21-4

AGRICULTURAL ENGINEER for sales, service, management, or plant maintenance engineering in power and machinery or product processing with industry. Any location. Willing to travel. Married. Age 34. No disability. BSAE 1950, University of Missouri. Farm background. Taught in trade school 4 years. Product development engineer on construction equipment 4 years. Navy 2 years, radarman 3/c. Available on reasonable notice. Salary open. W-31-5

AGRICULTURAL ENGINEER for design, development of research in power and machinery or soil and water field with experiment station, manufacturer, or consultant. Western location. Single. Age 24. No disability. BSAE, 1955, Fresno State College. Farm background. Part time work with land surveyor while in college. Nine months on sewer and storm drain design with civil engineer. U. S. Army 2 years as bandsman. Available June 1. Salary $400-450 per month. W-33-6

. . . Event Calendar

(Continued from page 105)

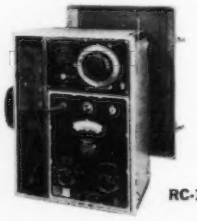
national Atomic Exposition, 6th Atomic Energy in Industry Conference, 6th Hot Laboratories and Equipment Conference, and the American Power Conference. For further information write to Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

March 16-22 — *National Wildlife Week* will stress the need for conserving public lands—parks and forests, wildlife, wilderness areas, grazing and mineral lands.

March 23-29 — *American Congress on Surveying and Mapping and the American Society of Photogrammetry Consecutive Meetings and Co-Exhibit,* Shoreham Hotel, Washington, D.C. For further information write ACSM-ASP, 1515 Massachusetts Ave., N.W., Washington 5, D.C.

April 11-18 — *Fifteenth International Horticultural Congress,* Nice, France, on the Cote d'Azur. The theme will be on science in the service of horticultural techniques.

BN-2


RC-12C1P

RD-15

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Measure moisture content and soluble salt or fertilizer content with easy-to-use Industrial Instruments Conductivity Bridges!

BOUYOUCOS TRANSISTORIZED MOISTURE METER . . . designed for simple, rapid field testing of available soil moisture. Connect meter to leads from buried soil blocks and read moisture content directly. Completely self-contained, uses 4 inexpensive penlight batteries lasting 2 years. Second meter scale calibrated in ohms measured resistance. BN-2 Meter complete with neck strap and batteries **$92.00**

Gypsum Soil Blocks—impregnated with plastic for extra-life. Stainless steel electrodes and 5 ft leads . . . . . CEL-WWD—each **$2.20**

MODEL RC-12C1P SOIL MOISTURE BRIDGE . . . high accuracy research instrument incorporating true Wheatstone Bridge circuit with 1000 cps bridge oscillator. Range 0.2 to 2,500,000 ohms with 1% accuracy except at extreme ends of scale. 84" effective scale length and built-in adjustable capacitance up to 21,000 mmf. Electron "eye" null indicator and earphones. Battery-operated and contained in portable carrying case **$250.00**

SOLU BRIDGE SOIL TESTER MODEL RD-15 . . . for laboratory testing of soil extract conductivity and particularly valuable for use by flower growers and in greenhouses. Simplest and easiest to use, the RD-15 is an AC Wheatstone Bridge, line operated, "eye" tube used for null indicator. Calibrated 10-1000 mhos x 10^{-5}. Manual temperature compensator 50-100°F. In gray wrinkle steel case, for 115V/50-60 cycle AC operation **$70.00**

Conductivity cell CEL-S2—sturdy molded polystyrene dip cell **$16.75**

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Industrial Instruments

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Originators of steel detachable sprocket chain. Locke Steel Chain has been standard equipment on high quality farm equipment since the turn of the century.

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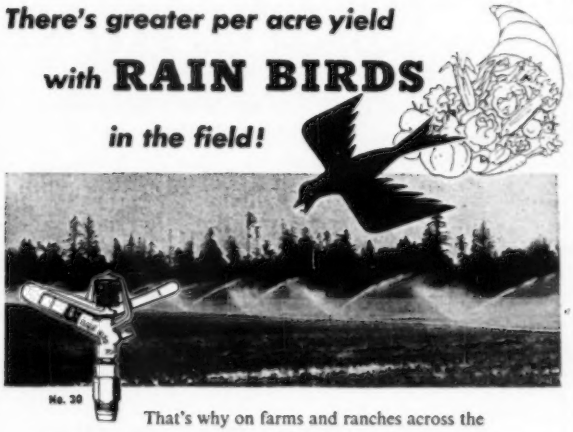
There's greater per acre yield

with **RAIN BIRDS**

in the field!



No. 30

That's why on farms and ranches across the nation . . . around the world, you'll find more RAIN BIRDS than any other type sprinkler.

Made with a minimum of moving parts to wear or require servicing, RAIN BIRDS stay on the job, performing day in and day out with maximum efficiency and dependability.

Remember, if it hasn't the name . . . it isn't the same. Specify RAIN BIRD!

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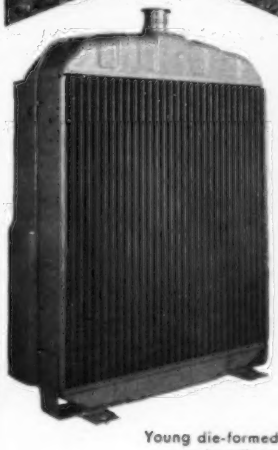

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Many good reasons why . . . . .

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These radiators are assembled from precision, die-formed parts. This precision fitting of parts and close unity of assembly provides the strength to withstand the severest jolting over rugged farm terrain.

When original equipment manufacturers—such as Allis-Chalmers—look for superior design and construction, better performance, dependability and economy, they know they can look to Young!

If you have a heat transfer problem, contact Young Radiator Company today for the solution. There's no obligation.

Young Radiators are used where the going is tough...

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Young **RADIATOR COMPANY**
RACINE, WISCONSIN

Creative HEAT TRANSFER ENGINEERS
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

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- Development, design, and application of farm tractors and implements and their components
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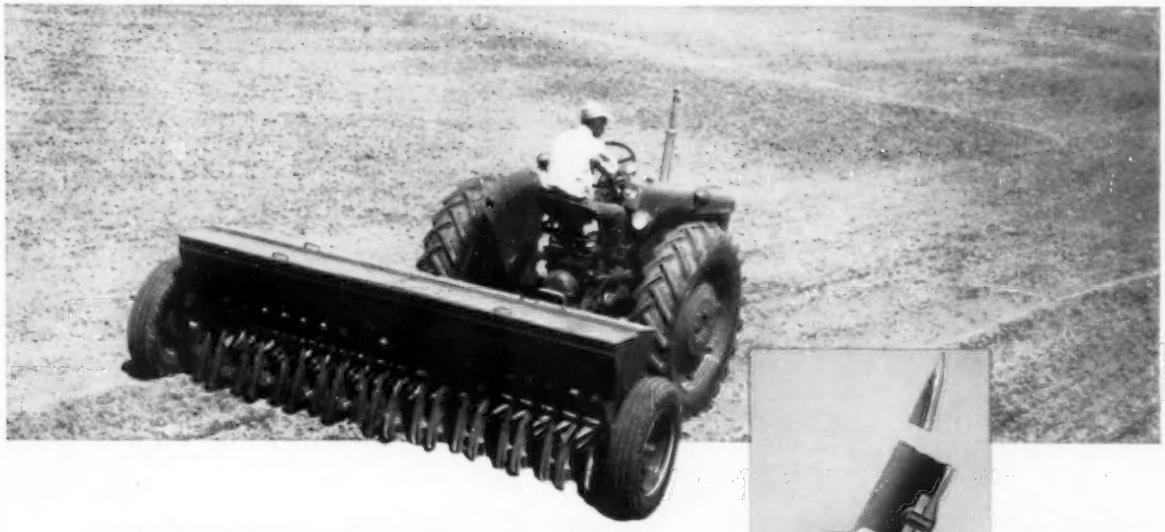
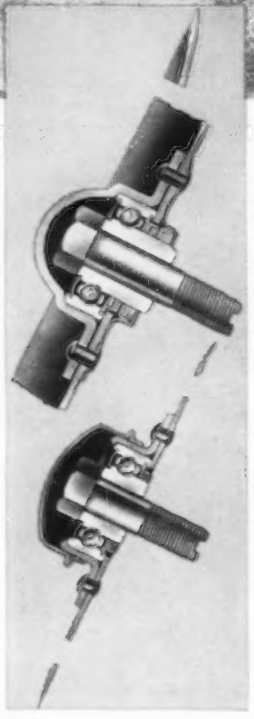
ND FACTS





Left, a Type I bearing in single-mounted grain drill disc. Recommended where extremely contaminated conditions require extra sealing precautions.

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That's right! There's no "downtime" for relubrication or other periodic attention!

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Count on New Departure, as do other leading farm implement manufacturers, to help you add *sales appeal* and *design simplicity* to your products.

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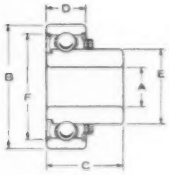
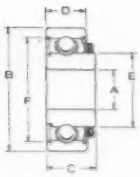


TYPE I

Type	Bearing	Bore A	O.D. B +.0000 −.0005	Inner Ring Width C ±.005	Outer Ring Width D ±.005	Inner Ring Outside Dia. E	Outer Ring Inside Dia. F
I	87504A16	.632 .626	1.8504	1.125	.5512	1.1585 1.1575	1.634
II	87504U	.632 .626	1.8504	.686	.5512	1.1585 1.1575	1.634



TYPE II

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DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

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New mower transmission uses TIMKEN® bearings throughout—even on pitman

New, smaller-design Timken bearings help John Deere gain economy and rugged dependability in mower design.

JOHN DEERE engineers know that Timken® bearings are designed and made to take the pounding shock and impact inherent in mower operation, especially in the pitman. By using the new, smaller standardized-size Timken Moto-Mated bearings, John Deere was able to keep its pitman design compact and also get vibrationless operation on its new No. 8 and No. 9 mowers.

These smaller, lighter, capacity-packed Timken Moto-Mated bearings save space and weight, permit more compact design. And because they're produced by revolutionary new methods, they cost less than previous designs.

Timken bearings are also used on the input shaft and crankshaft of the new mowers to assure accurate alignment under severe operating conditions. To get positive sealing and to minimize space, John Deere uses Timken bearings with the new "Duo-face" seal at the inner pitman position, adjacent to the flywheel on the crankshaft. This new bearing-seal unit gives 2-way sealing. It also cuts installation costs because it is pre-assembled.

Timken tapered roller bearings are geometrically designed and precision-made to roll true. Their taper lets them take both radial and thrust loads in any combination. They give agricultural engineers money-saving answers to design problems involving 1) loads, 2) dirt, 3) ease of operation.

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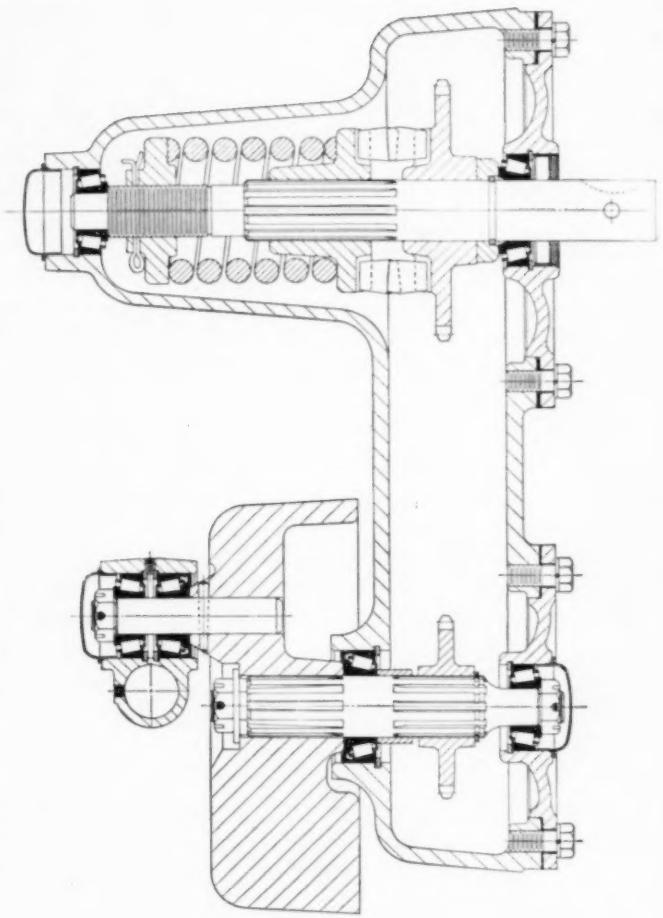

NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

The farmer's assurance of better design

Tapered Roller TIMKEN BEARING EQUIPPED

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